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Systematics, Biostratigraphy and Evolution of the Late Ludlow and Přídolí (Late Silurian) Graptolites of the Yass District, New South Wales, Australia

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ABSTRACT. Graptolites from the Yass district of New South Wales include important material from: low in the Black Bog Shale; from the Yarwood Siltstone Member; 2 levels high in the Black Bog Shale; 2 levels low in the Rosebank Shale; low in the Cowridge Siltstone; and in the lower part of the Elmside Formation. The faunas from the lower 4 levels are late Ludlow (early Late Silurian), and the higher 4 levels are Přídolí (late Late Silurian).

Twenty-seven graptolite taxa, a considerable increase on previous records from Yass, have been identified in the late Ludlow and Přídolí of the district. These taxa enable the Ludlow-Přídolí boundary to be identified some 20 m above the base of the Rosebank Shale (Booroo Ponds Group); our stratigraphically highest collection from the Elmside Formation is latest Přídolí, supporting the previous placement of the base of the Devonian approximately midway through the Elmside Formation (Barambogie Group). The following graptolite Biozones have been identified: *praecornutus, cornutus, parultimus, bouceki* and *transgrediens*. Twenty Yass taxa are described, including the new species *Bohemograptus paracornutus, Pristiograptus shearsbyi, Neocucullograptus? yassensis* and *N.? mitchelli* and the new subspecies *Monograptus perneri elmsidensis* and *M. formosus jenkinsi*. The following are recorded from Australia for the first time: *Bohemograptus praecornutus* Urbanek, 1970; *Crinitograptus operculatus* Münch, 1938; and *Pristiograptus kolednikensis* Přibyl, 1940. *Dictyonema* sp. cf. *D. sherrardae* Rickards *et al.*, 1995 and *D. elegans* Bulman, 1928 are considered late evolutionary derivatives of long-ranging dendroid species. *Linograptus posthumus introversus* Rickards & Wright, 1997 is interpreted as a short-lived, late Ludlow offshoot of the long-ranging *L. p. posthumus* Richter, 1875. *Bohemograptus praecornutus* is regarded as the ancestor of *B. paracornutus*, the *B. cornutus* evolutionary plexus being recognised for the first time in Australia. Late forms of *Pristiograptus dubius* (Suess, 1851) probably gave rise to *P. shearsbyi* n.sp. and *Pristiograptus kolednikensis* probably arose in the basal Přídolí from the late Ludlow *P. fragmentalis* (Bouček, 1936). Some material described and discussed by Brown & Sherrard (1952) is reinterpreted.

Bohemograptus paratenuis n.sp. is proposed for material assigned by Urbanek (1970) to *B. bohemicus* aff. *tenuis* (Bouček, 1936); this species is known only from Poland.

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The Yass Silurian sequence of New South Wales has been recognised as one of the most important developments of the system in Australia (Jell & Talent, 1989). Among the fossil groups abundantly represented in the Yass strata, conodonts and graptolites are the most important for determining the age relationships of the strata; the conodont faunas were described by Link & Druce (1972) but the graptolites have been, by comparison, poorly known. In this paper we identify the graptolite faunas from a number of stratigraphic levels in the Yass sequence, and determine the ages and evolutionary relationships of the faunas.

The early explorer-geologist Strzelecki (1845) was the first to note the occurrence in the Yass district of strata we now recognise as Silurian. Graptolites from the Yass Silurian were first noted by the local schoolteacher, John Mitchell (1886, 1888: from "Bowning Beds, Bowning" and "Bell [sic] Vale"). The first brief graptolite description (as "allied to *M. dubius*") and illustration were by T.S. Hall (1903: Bowning Series, Belle Vale). Although "Belle Vale" is still a well-known property on the Black Range Road in the Yass district (Fig. 1), these reports are of historic interest only as the locality and material are not recognisable from published data. A.J. Shearsby, a local photographer and keen amateur geologist, noted in 1912 the graptolites *Monograptus* (?) and *Dendrograptus* from strata identified by him as the "Barrandella shales".

The stratigraphic terminology for the Silurian strata of the area has evolved considerably from the pioneering descriptions by Shearsby (1912) and Brown (1941), to the current stratigraphic terminology proposed by Link (1970), followed by Link & Druce (1972) in their seminal studies of conodonts from the Yass Silurian, and finally modified by Cramsie *et al.* (1978).

Sherrard & Keble (1937) described Ordovician and Silurian graptolites from the Yass area. Surprisingly (in view of the abundant graptolites at other levels in the Yass Silurian sequence) the Silurian graptolites they described were Přídolí forms from near "Silverdale" NNW of Yass (Fig. 1), under the names of *Monograptus flemingii* (Salter), *M.*

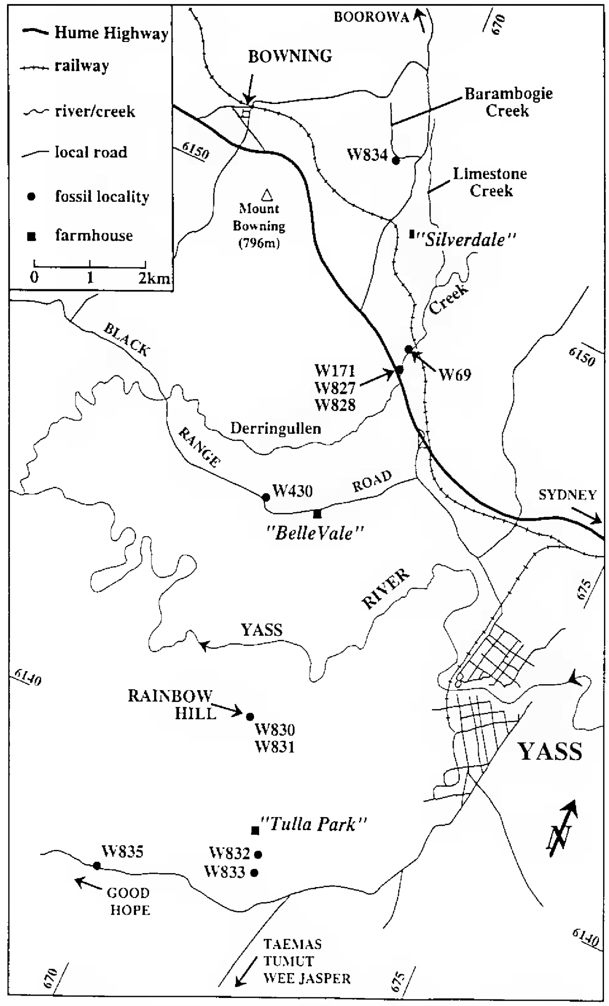

Figure 1. Locality map for the Yass district. Geological details can be obtained from Link & Druce (1972). The 3 and 4 digit numbers adjacent to short lines along the figure margins indicate the metric grid for the Yass 8628-S 50 000 map sheet.

Table 1. A comparison of previously identified graptolites from the Yass district, and present identifications of Yass graptolites.

Sherrard & Keble, 1937	Brown & Sherrard, 1952	Jaeger, 1967	Packham, 1968	this paper
	M. bohemicus	*M. bohemicus* subsp. B		*Bohemograptus paracornutus* n.sp.
M. cf. *nilssoni*	*M. nilssoni*	*Linograptus p. posthumus*		*L. p. posthumus*
				L. p. introversus
	M. roemeri	*M. bohemicus*		*B. paracornutus* n.sp.
	M. crinitus	*M. scanicus* group		?*L. p. posthumus*
M. cf. *tumescens*		*M. dubius* group	*M.* cf. *ultimus*	*M. parultimus*
M. flemingii	*M. salweyi*	*M. bouceki*		*M. bouceki*
M. cf. *vomerinus*		*M. transgrediens*		*M. transgrediens*
M. cf. *nilssoni*				
		M. bohemicus subsp. A		*B. praecornutus*
		M. formosus	*M. formosus*	*M. formosus*

cf. *tumescens* Wood, *M.* cf. *vomerinus* (Nicholson), *M.* sp. cf. *M. nilssoni* (Barrande) and *Dictyonema* sp.

A more significant step in the study of the graptolites of the Yass district was made by Brown & Sherrard (1952), who first drew attention to the existence of what has traditionally been known as the "*Monograptus bohemicus*" fauna at Yass. Subsequent work on this "*bohemicus*" fauna (now best known from Rainbow Hill) has been limited to a few preliminary comments by Jaeger (1967), which are discussed as appropriate in the taxonomic section of this paper. Brown & Sherrard described this "*bohemicus*" fauna under the names of *Monograptus bohemicus* Barrande, 1850, *M. nilssoni, M. crinitus* Wood, *M. roemeri* (Barrande) and *Dictyonema* sp. We have restudied their illustrated "*bohemicus*" material and conclude that it is (1) not *B. b. bohemicus* but *B. b. tenuis* (Bouček, 1936), and (2) possibly is not from Rainbow Hill but from exposures of a slightly different level (B, probably just below our level 2: see Fig. 2) high in the Black Bog Shale, possibly along strike towards the Yass River (Fig. 1). Some of Brown & Sherrard's illustrated graptolites are re-illustrated in Fig. 11 and re-identified in Table 1 herein. Brown & Sherrard also restudied the "Silverdale" fauna, from which they determined and described *Monograptus salweyi* (Hopkinson), *M.* sp. cf. *M. tumescens* Wood and *Dictyonema*.

Both Jaeger (1967) and Packham (1968) studied graptolites from levels other than those studied by Brown & Sherrard (1952). Packham identified *Monograptus formosus* Bouček, 1931b and *Monograptus* cf. *M. ultimus* Perner, 1899 from the Rosebank Shale at the junction of the (then) Hume Highway and Derringullen Creek, above the unit now known as the Rainbow Hill Marl Member of the Rosebank Shale (Link & Druce, 1972), and considered this fauna basal Přídolí, with which we concur.

Jaeger (1967) commented briefly on graptolites from three levels in the Yass sequence. Firstly, he studied the graptolite fauna previously studied by Sherrard & Keble (1937) from the lower part of the Cowridge Siltstone at the locality known as "Silverdale" (Fig. 1), which is close to our locality W834. He showed that these former workers had incorrectly identified *Monograptus bouceki* Přibyl, 1940 as *Monograptus salweyi* from this locality; he also recorded *Monograptus transgrediens* Perner, 1899 from his "Silverdale" material, and considered the fauna to be Přídolí. Secondly, he identified *Monograptus formosus* and "*M.* sp. of the *M. dubius* group" from Packham's (1968) locality, and the latter also from the locality near the Good Hope road (see Brown & Sherrard, 1952, fig. 1). Thirdly, he made interesting preliminary comments on the bohemograptids from below the Rainbow Hill Marl, from an unspecified locality. With regard to his collections from Yass (and Quarry Creek, cited by Jaeger, 1991), recent information suggests that these collections may be in the Humboldt Museum in Berlin.

The most recent advance in the study of Yass Silurian graptolites was by Jenkins (1982) who described a latest Přídolí fauna from the lower part of the Elmside Formation. Some Elmside material illustrated by Jenkins (1982) is refigured here in Fig. 12.

Despite the above record of graptolite research, the Yass sequence of Silurian graptolites has remained poorly known by world standards; in particular, the supposed "*Monograptus bohemicus*" fauna from the topmost beds of the Black Bog Shale has remained essentially unstudied for almost 45 years.

Our stratigraphically lowest specimens are from the Black Bog Shale, although Shearsby (1912), Jaeger (1967) and Cramsie *et al.* (1978) reported material from lower in the sequence. We have made new graptolite collections from most of the important localities mentioned by the above workers, as well as other localities, and now have 27 graptolite taxa from the area, spanning the Ludlow-Přídolí interval. This work has significantly extended the faunal diversity previously noted from most localities; some newly recorded taxa are surprisingly common in our collections.

Materials and method

Material cited and figured in this study is deposited in the Australian Museum; a supplementary collection is held for comparative purposes in the Sedgwick Museum, Department of Earth Sciences, University of Cambridge. "AMF" are Australian Museum numbers and "SM X." are Sedgwick Museum. Material reported by Jaeger (1967) has not been available for study, but it may be in the Humboldt Museum für Naturkunde, Berlin. However, with the exception of *Monograptus formosus* we have ample duplicate collections. Most taxa plotted on Fig. 2 are here both illustrated and described, but a few are merely illustrated. Elmside Formation specimens described by Jenkins (1982) have not been redescribed here, except for *M. formosus jenkinsi* n.subsp. (=*M. formosus* of Jenkins), *M. transgrediens* and *M. hornyi* (=*M.* cf. *angustidens* of Jenkins).

The graptolites are preserved in a variety of rock types from fine mudrock and shale to medium sandstones. Often they are in full relief. There is some slight tectonic deformation at some localities, and is indicated as appropriate on the illustrations; not all specimens from any one locality appear to be affected in the same way. There is some soft sediment deformation, especially of more slender species. However, in general the material is excellently preserved and more or less undeformed. The taxonomy is that recently used by Rickards *et al.* (1995), Rickards & Wright (1997) and Koren′ & Sujarkova (1997). Measurements of thecal spacing are given in the manner devised by Packham (1962), which we prefer to Howe's (1983) 2TRD technique: the latter we find less readable and more difficult to compare quickly with older methods of measurement. Σ is the distance from the sicular aperture to the most distal extremity of the first theca.

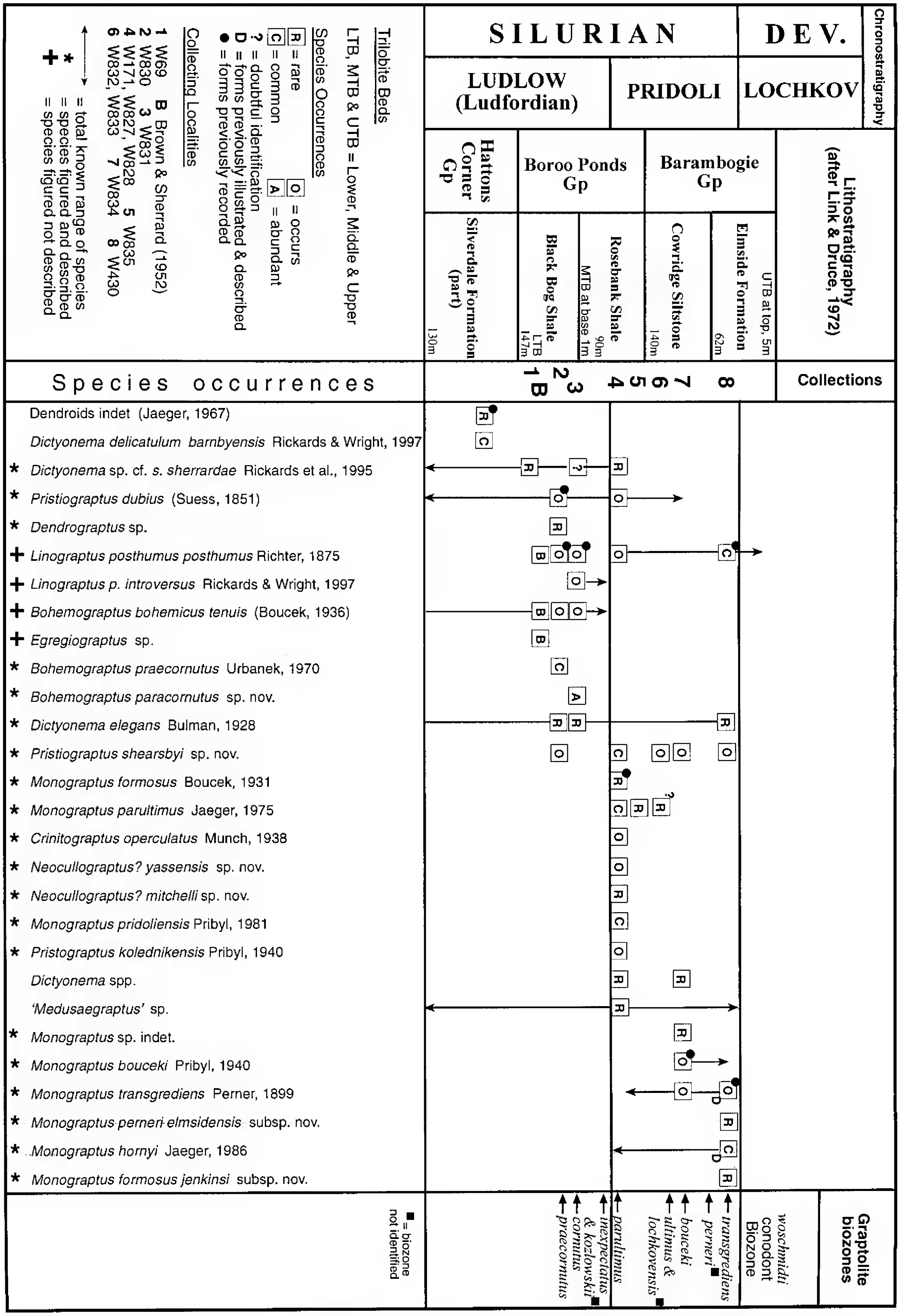

Figure 2. Ranges of identified graptolites plotted against lithostratigraphy and proposed biostratigraphy and chronostratigraphy. Elmside Formation occurrences are partly after Jenkins (1982). The symbols indicating numbers of specimens are approximately: R, 1–10; O, 15–50; C, 50 to several hundreds; and A, thousands. The symbol B indicates the level of Brown & Sherrard's collections; only single slabs are in their collections, so abundances are unknown.

Systematic palaeontology

Class **Graptolithina** Bronn, 1849

Order **Dendroidea** Nicholson, 1872

Family **Dendrograptidae** Roemer, in Frech, 1897

Dendrograptus J. Hall, 1858

Type species. *Graptolithus hallianus* Prout, 1851; subsequently designated by J. Hall (1862).

Dendrograptus sp.

Fig. 3A

Material. A single specimen AMF 92368, from locality W830, *praecornutus* Biozone, late Ludlow, Black Bog Shale.

Description. The single fragment is a little over 7 mm long, with five branching divisions of typical *Dendrograptus* style. Autothecae are seen in one part and have a spacing of 20 in 10 mm. Dorsoventral stipe width is about 0.40 mm, assuming the lowest stipe is in true profile. Lateral stipe width is 0.15–0.40 mm, declining distally, suggesting that this portion of stipe is towards the extremity of the rhabdosome.

Remarks. *Dendrograptus* is a rare genus in the Silurian of NSW and only one specimen has been found in the Yass district. Rickards & Wright (1997) recorded five unidentifiable fragments from the Barnby Hills Shale; from the Quarry Creek region Rickards *et al*. (1995) recorded sparse, specifically unidentifiable fragments in the Wenlock and others, possibly conspecific with the Wenlock form, at two levels in the early Ludlow. It was suggested in the latter paper that the fragmentary nature of the rhabdosome, which is no less robust than other well-preserved dendroids occurring with them, may indicate a longer and more turbulent preservational history or, perhaps, a more distant, further inshore, provenance.

Dictyonema J. Hall, 1851

Type species. *Gorgonia retiformis* J. Hall, 1843; subsequently designated by Miller (1889).

Dictyonema sp. cf. *D. sherrardae sherrardae* Rickards *et al*., 1995

Fig. 3B

?1952 *Dictyonema* sp.; Brown & Sherrard, p. 133, pl. VIII, fig. e.
cf. 1995 *Dictyonema sherrardae sherrardae* Rickards *et al*., p. 20, figs. 11A–C, 12D,E, 13A,B.

Material. A small number of fragmentary specimens including: AMF 92369 from locality W69, Black Bog Shale from Ludlow, pre-*praecornutus* Biozone; and AMF 103037–44 from locality W171, Rosebank Shale, Přídolí, *parultimus* Biozone, ?AMF 44611 (Brown & Sherrard, 1952, pl. VIII, fig. e).

Description. Thecae with pronounced dorsal apertural process occupying fully half of the dorsoventral width of 0.80–0.95 mm and directed ventrally. Autothecal spacing about 20 in 10 mm. Bithecae not detected. Lateral stipe width about 0.30–0.40 mm.

Remarks. This is the first possible record of the *sherrardae* group in the Přídolí, as the two previously known Ludlow occurrences are in the *nilssoni* Biozone (Rickards *et al*., 1995) and the *inexspectatus-kozlowskii* Biozone (Rickards & Wright, 1997). The Yass material is close to the type subspecies in thecal spacing and dorsoventral stipe width, but we have no data on dissepimental spacing and stipe spacing, and no information on dissepiment type. *Dictyonema s. mumbilensis* Rickards & Wright (1997: 215–216) from the late Ludlow *inexspectatus/kozlowskii* level of the Wellington district (and here reported from Barrandella Shale Member of the Silverdale Formation [Fig. 2] at Yass) is a more slender form with a higher thecal spacing which may represent an offshoot of the main lineage.

Dictyonema elegans Bulman, 1928

Figs. 3C,D

1928 *Dictyonema elegans* sp. Bulman, p. 52, text-fig. 26; pl. 6, figs. 2–3.
1984 *Dictyonema (Dictyonema) elegans* Bulman; Kraft, p. 402; pl. 1, figs. 2–4.
1995 *Dictyonema elegans* Bulman, 1928; Rickards *et al*., p. 22, figs. 14C,D.
1997 *Dictyonema elegans* Bulman, 1928; Rickards & Wright, p. 214, figs. 5C, 8D.
?1997 *Dictyonema* cf. *elegans* Bulman, 1928; Rickards & Wright, p. 214, fig. 5D.
1997 *Dictyonema ?elegans* Bulman, 1928; Rickards & Wright, p. 214, fig. 6B.

Material. Upper beds of Black Bog Shale, late Ludlow: AMF 92366 from locality W830, *praecornutus* Biozone; AMF 102899 from W831, *cornutus* Biozone. One specimen (AMF 102890) from locality W430, late Přídolí; Elmside Formation, Black Range Road.

Description. Lateral stipe widths up to 0.25–0.30 mm and dorsoventral stipe widths 0.44–0.55 mm, including pronounced ventral processes. No obvious dorsal apertural processes. Interstipe spaces up to 0.40–0.60 mm. Stipe spacing approximately 20 in 10 mm, but the fragments do not allow a good measurement of dissepimental spacing. It is possible that the ventral apertural processes become spinose distally (see Fig. 3C) but these may, in fact, be slender dissepiments. Autothecal spacing about 30 in 10 mm.

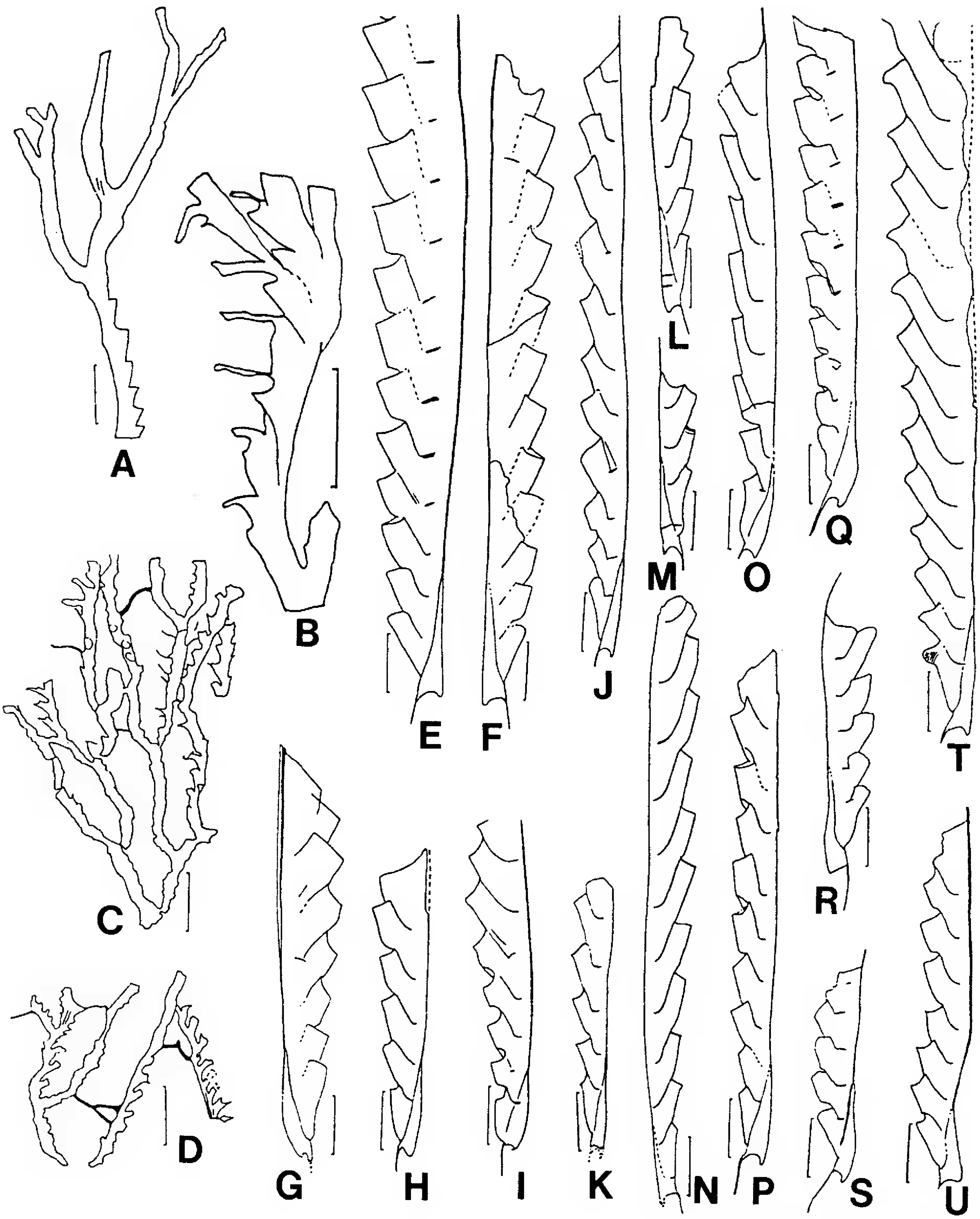

Figure 3. **A**, *Dendrograptus* sp., AMF 92368, W830, Black Bog Shale, *praecornutus* Biozone. **B**, *Dictyonema* sp. cf. *D. sherrardae sherrardae* Rickards *et al*., 1995, AMF 92369, W69, Black Bog Shale, Derringullen Creek. **C,D**, *Dictyonema elegans* Bulman, 1928; respectively AMF 102890, W430, Elmside Formation, *transgrediens* Biozone; and AMF 92366, W830, Black Bog Shale, *praecornutus* Biozone. **E,F**, *Pristiograptus kolednikensis* Přibyl, 1940, respectively AMF 92353–54, probably W171, Rosebank Shale, near crossing of Hume Highway and Derringullen Creek. **G–I**, *Pristiograptus dubius* Suess, 1851, respectively AMF 92359, AMF 92356, AMF 92360, W830, Black Bog Shale, *praecornutus* Biozone. **J–P**, *Pristiograptus shearsbyi* n.sp., respectively AMF 92358, W830, Black Bog Shale, *praecornutus* Biozone; AMF 92385, W833, base of Cowridge Siltstone; AMF 92345, W827, Rosebank Shale, *parultimus* Biozone; AMF 92395, holotype AMF 92392 and AMF 92394, W834, Cowridge Siltstone, *bouceki* Biozone; AMF 92344, W827, Rosebank Shale, *parultimus* Biozone. **Q–S,U**, *Monograptus parultimus* Jaeger, 1975; respectively AMF 102894, W171, Rosebank Shale, *parultimus* Biozone; AMF 92361, W171, Rosebank Shale, *parultimus* Biozone; AMF 92383, W171, Rosebank Shale, *parultimus* Biozone; AMF 92349, W827, Rosebank Shale, *parultimus* Biozone. **T**, *Monograptus transgrediens* Perner, 1899, AMF 92393, W834, Cowridge Siltstone, *bouceki* Biozone. Scale bars 1 mm.

Remarks. Bulman (1928) recorded the species from the late Wenlock and Rickards *et al*. (1995) extended its range into the Ludlow (*nilssoni* Biozone). There seemed to be more variation in the specimens recorded by Rickards & Wright (1997) from the Barnby Hills Shale (*inexspectatus–kozlowskii* Biozone, late Ludlow) and, in addition to *D. elegans*, they recorded *D.* cf. *elegans* and *D. ?elegans*. The last we now feel more confident in placing with the specimens of *D. elegans* of the Barnby Hills Shale: it should be noted that the autothecal spacing of these specimens (at 20 in 10 mm) contrasts with Bulman's originals and with the Quarry Creek specimens (both 25 in 10 mm) as well as with the present material (30 in 10 mm). Thus there is no linear decrease in thecal size from the Wenlock to the late Přídolí, so *D. elegans* presently has little biostratigraphic utility in the Late Silurian. The form described as *D.* cf. *elegans* from the Barnby Hills Shale (Rickards & Wright, 1997) may yet prove to be a new species smaller than, but closely related to, *D. elegans* Bulman.

Order **Graptoloidea** Lapworth, 1875

Family **Monograptidae** Lapworth, 1873

Pristiograptus Jaekel, 1889

Type species. *Pristiograptus frequens* Jaekel, 1889, by original designation.

Pristiograptus kolednikensis Přibyl, 1940

Figs. 3E,F, 4A, 13F

1940 *Monograptus (Pristiograptus) kolednikensis* Přibyl, p. 70, text-figs. 1–8.
1943 *Pristiograptus kolednikensis* Přibyl, 1940; Přibyl, p. 20–21; text-figs. 2I,J; text-figs. 3L,M.

Material. Figured specimens AMF 92353–54 (formerly numbered University of Wollongong F1872), AMF 92365 (formerly University of Wollongong F886) and numerous other specimens (AMF 103090–94, AMF 103102, SM X.28018–22, SM X.28056–57) from localities W171, 827 and 828, *parultimus* Biozone (Přídolí), Rosebank Shale.

Diagnosis. *Pristiograptus* with sicula 2.00–2.20 mm long, apex at level of th 2 aperture; rhabdosome more or less straight; dorsoventral width 0.70–0.90 mm at level of th 1, to 1.12–1.72 mm at th 10 and up to 2.20 mm most distally; thecal spacing 11–12 in 10 mm proximally to 9–10 in 10 mm distally; thecal overlap around ½; thecal inclination 20–30°; thecal aperture of th 1 sometimes slightly rounded, but no other apertural modifications seen. $\Sigma = 1.04–1.10$

Remarks. These specimens are clearly very close to *Pristiograptus fragmentalis* (Bouček, 1936) especially as recently redescribed by Koren′ & Sujarkova (1997) from the late Ludlow of south Tien Shan. They differ only in having a smaller Σ value and in having lower distal dorsoventral width (2.20 mm maximum compared with 2.2–2.8 mm). All previous descriptions of *P. fragmentalis* confirm its high dorsoventral width. Jaeger (*in* Kříž *et al*., 1986) was of the opinion that the early growth stages of *P. fragmentalis* (and, presumably, very similar forms such as *P. kolednikensis*) were very difficult to distinguish from *P. dubius*. Whilst there is some truth in this, especially when the proximal end shows a slight ventral curvature, it seems to us that not only is the proximal end more commonly straight, but that the angle of thecal inclination of the early thecae is higher in *P. kolednikensis* and *P. fragmentalis* (contrast, for example, Figs. 3E,F and Figs. 3G–I herein; and see Koren′ & Sujarkova, 1997, text-fig. 7). Further comment on the evolution of *P. kolednikensis* is given in the evolution section. The specimen AMF 92365 is shown as Fig. 4A for direct comparison with *M. transgrediens* (Perner, 1899; Figs. 4B–E herein).

This is the first report of this species from Australia.

Pristiograptus dubius (Suess, 1851)

Figs. 3G–I

1850 *Graptolithus colonus* Barr.; Barrande, p. 43, pl. 2, fig. 5.
1851 *Graptolithus dubius* Suess, p. 115, pl. 9, figs. 5a,b.
1943 *Pristiograptus dubius dubius* (Suess, 1851); Přibyl, p. 3, pl. 1, figs. 4–6.
1958 *Pristiograptus dubius* (Suess); Urbanek, p. 83–87, text-fig. 57; pl. 5, figs. 1, 2; text-pl. 7.
1986 *Pristiograptus dubius* (Suess); Koren′, p. 119–122, pl. XXIX–XXX, text-figs. 27–29.

Material. Figured specimens (AMF 92356, 92359, 92360) all from locality W830, *praecornutus* Biozone, Black Bog Shale, late Ludlow; other specimens from the same locality are AMF 103045–52, SM X.28024–28.

Remarks. Although fitting previous descriptions fairly closely, this material exhibits some variation in sicular length from 1.40–1.88 mm. The position of the apex remains the same—midway between the apertures of th 1 and th 2—and in consequence the thecal spacing of the early thecae on those rhabdosomes with a shorter sicula is higher (15 in 10 mm compared with the more usual 12 in 10 mm; see, for example, Figs. 3G,I).

In general, *P. dubius* has been rarely illustrated or described from stratigraphic levels towards the end of its long range (early Wenlock to Přídolí); for example, it was recorded from as high as the *ultimus* Biozone (Přídolí) by Koren′ & Sujarkova (1997) but was neither figured nor described. Bearing in mind that *P. dubius* is one of the longest-ranging lineages (ranging through approximately 18 Ma) it would be useful to document its occurrences carefully. Our material shows a rather more pronounced dorsal sicular tongue (Figs. 3G–I) than do stratigraphically lower forms of *P. dubius*, but we have no way of knowing whether this is a general feature of stratigraphically high forms.

Pristiograptus shearsbyi n.sp.

Figs. 3J–P, 11A,B, 13B,E

Material. HOLOTYPE AMF 92392, locality W834, Cowridge Siltstone, Barambogie Creek, *bouceki* Biozone, Přídolí; specimen in three dimensions. PARATYPES. AMF 92385, locality W835, Rosebank Shale; AMF 92344–45, locality W827, *parultimus* Biozone, Rosebank Shale; AMF 92394–95, locality W834, *bouceki* Biozone, Cowridge Siltstone. Rare at locality W830, Black Bog Shale (AMF 92358), Ludlow. Numerous Přídolí specimens from localities W171, W827, W828, W835, Rosebank Shale; W832, W833, W834 from the Cowridge Siltstone (AMF 102956–60, 103004–12, 103017–18, 103023–25, 103095–101, 103103, SM X.27111–12, SM X.28029–31, SM X.28041–48); and from the Elmside Formation, locality W430 (AMF 102926, AMF 103053).

Etymology. After A.J. Shearsby, photographer and pioneer geologist in Yass.

Diagnosis. Straight, thin *Pristiograptus* rhabdosomes, up to 12 mm long and with a maximum dorsoventral width (flattened) of 0.85 mm; proximal dorsoventral width 0.40–0.55 mm; sicula 1.20–1.65 mm, apex reaching midway between apertures of th 1 and th 2; Σ=1.2–1.4; thecal overlap about ½; thecal inclination 10–30°; proximal thecal spacing 11–12 in 10 mm; distal thecal spacing 9–10 in 10 mm; th 1 very rarely shows a slight rounding of the aperture; sicula with short but pronounced dorsal tongue.

Description. The proximal end is mostly quite straight, but a minority of specimens shows a very gentle ventral curvature (e.g., Figs. 3J,N,O). Occasionally, as in Fig. 3K, the apex of the sicula reaches to the level of the aperture of th 2, and it may be that the difficult-to-see prosicula usually reaches that level. The thecal overlap seems to vary slightly from just under ½ (e.g., Fig. 3J) to almost exactly ½ (Fig. 3N). The rounding seen rarely on th 1 is no more than that commonly seen in *P. dubius*, and all the thecae are essentially pristiograptid in nature. There is a very slight geniculum identifiable in some specimens (Fig. 3P) though not to the extent seen in *Pseudomonoclimacis* Mikhajlova, 1975.

Remarks. This is the first record of a slim pristiograptid from the Yass region in late Ludlow and Přídolí strata; Jaeger (1967) referred to pristiograptids of the *dubius* group from the Rosebank Shale, but not from the Cowridge Siltstone where we have found them commonly with *M. bouceki* and *M. transgrediens* on Barambogie Creek. Similarly the slender *Crinitograptus* and *Neocucullograptus* from localities W171, W827 and W828, which we describe below, have not been previously reported from these localities, although they also occur with *P. shearsbyi* n.sp. Koren′ & Sujarkova (1997) recorded *P. dubius* from as high as the *ultimus* Biozone and *P.* ex gr. *dubius* from a little higher (*tumultuosus* Biozone: they are not described or figured herein).

Other slender pristiograptids of the *dubius* group occur from the late Llandovery to the middle Ludlow. Usually they are of short duration, repeatedly arising from the stem lineage of *P. dubius*, and are difficult to distinguish one from another in view of the few available biocharacters. *Pristiograptus shearsbyi* n.sp. differs from earlier slender pristiograptids, however, in having a pronounced dorsal tongue to the sicular aperture, a feature which affects many graptoloid lineages in the late Ludlow and Přídolí. The more robust *P. dubius* (Figs. 3G–I) is similarly affected at this stratigraphic level. In lacking thickening at the base of the interthecal septum, this species is distinct from *Pseudomonoclimacis*.

Monograptus Geinitz, 1852

Type species. *Lomatoceras priodon* Bronn, 1835; subsequently designated by Bassler (1915).

Remarks. In this paper we follow the taxonomy of Koren′ & Sujarkova (1997, p. 66–67) in using a broadly-conceived *Monograptus*, arguing that recognition of genera such as *Istrograptus* Tsegelnjuk, 1988, *Scalograptus* Tsegelnjuk, 1976 and *Neocolonograptus* Urbanek, 1997 is premature: a better understanding of the evolutionary lineages is necessary before these taxa can be accepted. Although some monograptids may have arisen from a pristiograptid stock, there has been no serious suggestion that they should be referred to a taxon such as "*Pristiograptus*".

Brown & Sherrard (1952) illustrated taxa attributed to *Monograptus bohemicus* (Barrande, 1850) from portion 15, parish of Hume; this specific identification has, hitherto, remained unchallenged. To date, only Jaeger (1967) has commented again on these monograptids; he believed there were two subspecies of *Monograptus bohemicus* present through what is essentially the upper section of the Black Bog Shale covered by our localities W830 to W831. Here we distinguish three species-level taxa of curved, *bohemicus*-type graptoloids, which we identify as *Bohemograptus tenuis, B. paracornutus* n.sp. and *B. praecornutus* Urbanek, 1970. No *B. b. bohemicus sensu stricto* has been confirmed from Yass as yet, although an ample thickness of the Black Bog Shale exists below our locality W830. Further, the "*M. bohemicus*" illustrated by Brown & Sherrard (1952, see locality map fig. 1) is from just below our localities W832 and W833 on "Tulla Park", despite the fact that they did have Rainbow Hill material collected by Gordon Packham (pers. comm., GHP). The material illustrated by Brown & Sherrard (1952, fig. 2d; pl. VIII, fig. d) as *M. bohemicus* is actually *M. b. tenuis* (Fig. 12B). Our re-identifications of the names they assigned to the illustrated graptolites are given in Table 1.

Monograptus parultimus Jaeger, 1975

Figs. 3Q–S,U

1968 *Monograptus* sp., cf. *Monograptus ultimus* Perner; Packham, p. 219–220; pl. 11, figs. 1–3, 5, 6.
1975 *Monograptus parultimus* Jaeger, p. 119–125, text-fig. 44; pl. 2, figs. 4, 8.
1986 *Monograptus parultimus* Jaeger, 1975; Jaeger *in* Kříž *et al.*, p. 318–321, text-figs. 29–34; pl. 1, figs. 1, 2, 5, 8, 9; pl. 2, figs. 3–6, 23, 24; pl. 4, fig. 12.
1988 *Ludensograptus parultimus* (Jaeger, 1975); Tsegelnjuk, p. 82, fig. 5.
1990 *Pseudomonoclimacis parultimus* (Jaeger, 1975); Lenz, p. 1081, figs. J–L.
1992 *Monograptus parultimus* Jaeger, 1975; Rickards & Banks, p. 10–11, fig. 1B; pl. 1B.
1997 *Monograptus parultimus* Jaeger; Koren′ & Sujarkova, p. 78–79, text-figs. 12A–Y; pl. 4, figs. 5–12; pl. 5, figs. 1–7.

[Further references were given by Jaeger (*in* Kříž *et al.*, 1986) and Rickards & Banks (1992)]

Material. Fairly common at Přídolí localities W171, W827 and W828 (AMF 92349, AMF 92361 [formerly numbered University of Wollongong F 520], AMF 92383–84, AMF 102894, AMF 103076, SM X.28023, SM X.28049), *parultimus* Biozone, Rosebank Shale; rare at Přídolí locality W835, possibly in Přídolí localities W832–3 (AMF 103019–22), post-*parultimus* Biozone, all low in Cowridge Siltstone.

Diagnosis. *Monograptus* with rhabdosomes usually less than 10 mm long and with a maximum dorsoventral width of about 1.30 mm at that length; proximal end and sicula often with slight ventral curvature; sicula with dorsal tongue and virgella often directed at 45° to the rhabdosomal axis; thecal apertures undulating, with slight elevations, especially th 1–th 3, thereafter declining somewhat, and often with thickened rims; thecal spacing proximally 11–13 in 10 mm; distal thecal spacing 9–11 in 10 mm; thecal overlap <½; slight geniculum; base of interthecal septum often thickened; Σ=1.1–1.5; sicula 1.70–1.90 mm; dorsoventral width at th 1, 0.60–0.80 mm; dorsoventral width at th 10, 1.00–1.40 mm.

Remarks. Our material is very close to the type material from Kosov Quarry (Jaeger *in* Kříž *et al.*, 1986), but is a little different in dimensions from the specimens described recently from south Tien Shan (Koren′ & Sujarkova, 1997) which are slightly wider and have a higher Σ value. The Yass specimens are also close to the Tasmanian specimens described by Rickards & Banks (1992), differing only in having slightly more of a geniculum as, indeed, does the type material; this is almost certainly a reflection of preservational differences. Sherwin (1979, p. 161) stated that the taxon identified by Packham (1968) as *M*. cf. *ultimus* was believed to be *M. tomczyki*.

Monograptus transgrediens Perner, 1899 *sensu lato*

Figs. 3T, 4B–E, 11C, 13A

1899 *Monograptus transgrediens* Perner, p. 13, pl. 17, fig. 24.
1940 *M. (Pristiograptus) transgrediens* Perner; Přibyl, p. 68–69.
1943 *Pristiograptus transgrediens* Perner; Přibyl, p. 30–31; pl. 2, fig. 7; pl. 3, fig. 7.
1964 *M. transgrediens* (Perner); Teller, p. 52, pl. 2, fig. 3; pl. 3, figs. 1–4; pl. 7, figs. 8–12.
1982 *Monograptus transgrediens* Perner 1899; Jenkins, p. 171, fig. 3M, N(?).
?1982 *Monograptus transgrediens* cf. *praecipuus* Přibyl, 1940; Jenkins, p. 171, figs. 3G,H.
1984 *Monograptus transgrediens transgrediens* Perner, 1899; Porebska, p. 141–144, figs. 13, 1–9.
1986 *Monograptus transgrediens* Perner; Koren′, p. 115–116, text-figs. 1–6, 25; pl. 27, figs. 1–6; pl. 28, figs. 1–5.
1986 *Monograptus transgrediens* Perner, 1899; Jaeger *in* Kříž *et al.*, p. 326–328, text-figs. 41a–c; pl. 1, figs. 15, 17, 18; pl. 2, figs. 12, 16, 17, 19, 22, 25.
1990 "*Pristiograptus*" *transgrediens* (Perner); Lenz, p. 1081, figs. P–R.
1997 *Monograptus transgrediens* Perner, 1899; Koren′ & Sujarkova, p. 81–83, text-figs. 15A–P; pl. 6, figs. 3–9.
1997 *Istrograptus transgrediens transgrediens* (Perner, 1899); Teller, p. 76–77; pl. 2, figs. 1–11.

Material. Common at locality W834 (AMF 92387, AMF 92389, AMF 92390, AMF 92391, AMF 92393), low in Cowridge Siltstone, Barambogie Creek, *bouceki* Biozone, Přídolí; and a few specimens from W430 (AMF 102927a, AMF 102939–47, AMF 102966–68, SM X.27094–100), Elmside Formation, Black Range Road, *transgrediens* Biozone, Přídolí.

Diagnosis. *Monograptus* with proximal end usually with slight ventral curvature, and rounding of the thecal apertures (raised lappets) visible sometimes even on th 7, though more commonly on th 1 to th 5; sicula with slight ventral curvature, dorsal tongue, a length of 1.60–1.90 mm, Σ=1.3–1.5, and an apex which reaches to the level of between the apertures of th 1, and th 2 (though with the prosicula not often visible); proximal thecal spacing 10–13 in 10 mm, distally about 10 in 10 mm; dorsoventral width at th 1 0.70–0.80 (in three dimensions) and distally 1.30–1.50 mm (three dimensional specimens). Rhabdosomes in the Elmside Formation reaching a length of 30 mm and a dorsoventral width of 1.80 mm.

Remarks. The type material was redescribed by Jaeger (*in* Kříž *et al.*, 1986) and our material is close to that except in being shorter and hence less robust; Jaeger (*in* Kříž *et al.*, 1986) recorded a maximum length of 100 mm and a maximum width of 3 mm. Although Koren′ & Sujarkova

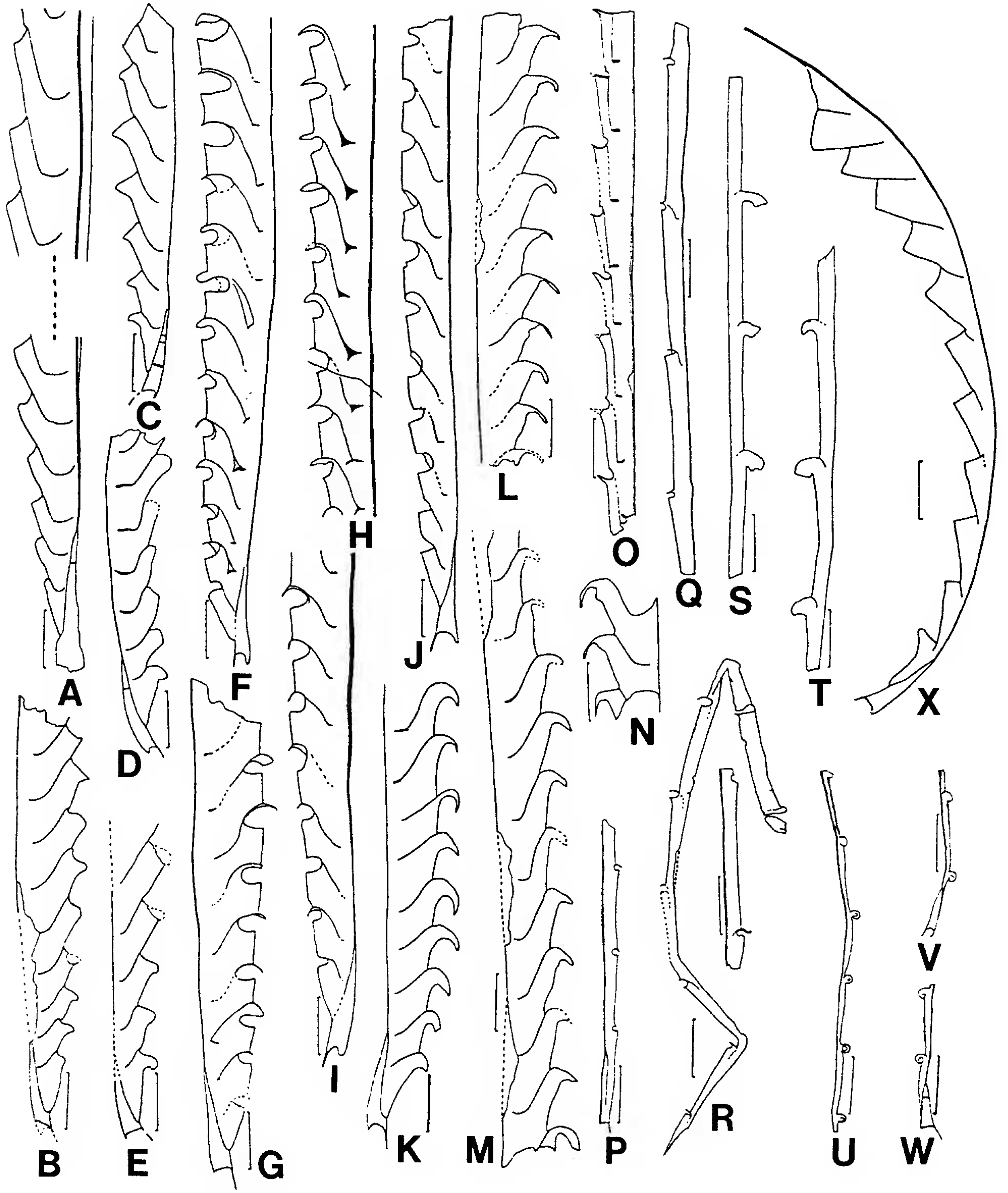

Figure 4. **A**, *Pristiograptus kolednikensis* Přibyl, 1940, AMF 92365, W171, Rosebank Shale, *parultimus* Biozone, for direct comparison with *M. transgrediens* (B–E). **B–E**, *Monograptus transgrediens* Perner, 1899, respectively AMF 92389, AMF 92391, AMF 92387, AMF 92390, W834, Cowridge Siltstone, *bouceki* Biozone. **F–I**, *Monograptus pridoliensis* Přibyl, 1981; respectively AMF 92352, AMF 92347, AMF 92351, AMF 92350, W827, Rosebank Shale, *parultimus* Biozone. **J**, *?Monograptus pridoliensis* Přibyl, 1981, AMF 92355, W171, Rosebank Shale, *parultimus* Biozone. **K–N**, *Monograptus bouceki* Přibyl, 1940, respectively, after Jaeger (1967, pl. 14, fig. A), AMF 92388, 92386, 92386b, W834, Cowridge Siltstone, *bouceki* Biozone. **O**, *Monograptus* sp. indet, AMF 102889, W834, Cowridge Siltstone, *bouceki* Biozone. **P–R**, *Crinitograptus operculatus* (Münch, 1938) respectively AMF 102891, AMF 102892, W171, Rosebank Shale, *parultimus* Biozone; and AMF 92342, W828, Rosebank Shale, *parultimus* Biozone. **S,T**, *Neocucullograptus? mitchelli* n.sp., holotype AMF 102895, W171, Rosebank Shale, *parultimus* Biozone. **U–W**, *Neocucullograptus? yassensis* n.sp., respectively AMF 92346, AMF 92344, holotype AMF 92343, W828, Rosebank Shale, *parultimus* Biozone. **X**, *Bohemograptus bohemicus tenuis* (Bouček, 1936), AMF 92339, W830, Black Bog Shale, *praecornutus* Biozone. Scale bars 1 mm.

(1997) commented on Jaeger's (*in* Kříž *et al.*, 1986) redescription of Perner's types, they did not refer to Jaeger's topotype material in their synonymy: the dimensions and form of their southern Tien Shan specimens are, however, very close to the Bohemian types. The Σ value is less in the types than either the southern Tien Shan material or the Yass material, both of which agree closely in this feature.

Monograptus transgrediens is a typical and long-ranging Přídolí species. Teller (1997) suggested that the number of beak-like thecae in "*Istrograptus*" increased gradually through the Přídolí, with "*Istrograptus*" *t. transgrediens* being typical of the highest levels with several beak-like thecae. However, our *bouceki* Biozone material has one to seven beak-like thecae, and the *transgrediens* Biozone Elmside Formation forms have far fewer, suggesting that more study of the described subspecies on a wider geographical basis is required before firm subspecific assignment can be achieved. Although Jenkins (1982) did not identify his figures 3M and 3N, we presume they represent his *M. transgrediens*. We are uncertain about the form he ascribed to *M. t.* cf. *praecipuus* (Jenkins' figs. 3G,H) and include it doubtfully in our synonymy of *M. transgrediens*. Jaeger (1967) noted that there were two forms present of *M. transgrediens* but we cannot confirm this from our material which may have a range of sizes from smaller earlier growth stages to "normal" late growth stages.

Monograptus pridoliensis Přibyl, 1981

Figs. 4F–I,?J, 13D

1940 *Monograptus (Pomatograptus) similis* Přibyl, p. 72, text-figs. 1, 3; pl. 1, fig. 5.
1981 *Monograptus pridoliensis* nom. nov.; Přibyl, p. 371–372, text-figs. 1, 3–6; pl. 1, fig. 1; pl. 2, fig. 6.
1986 *Monograptus pridoliensis* Přibyl, 1981; Jaeger *in* Kříž *et al.*, p. 328–330, text-fig. 42; pl. 3, figs. 1, 12; pl. 4, figs. 2, 3, 8, 9, 11.
1990 *Monograptus* cf. *pridoliensis* Přibyl; Rickards & Garratt, p. 43–44, figs. 4a–f.

Material. Numerous specimens from localities W171, W827, W828 (AMF 92347–48, AMF 92350–51, AMF 92352, ?AMF 92355 (formerly University of Wollongong F 1872), AMF 103077–89, SM X.28052–55), *parultimus* Biozone, Rosebank Shale, Přídolí.

Diagnosis. *Monograptus* with more or less straight rhabdosome but with dorsal margin showing slight ventral curvature over the first few thecae; sicula effectively straightens the rhabdosome outline, even giving a slight dorsal flexure (Fig. 4F) in some specimens; sicula 1.50–2.0 mm long; Σ=1.2–1.5; sicular apex almost to level of second thecal aperture; dorsal sicular tongue; slight ventral curvature of sicula common; thecae with pronounced hoods which lessen a little distally; thecal overlap about ½ proximally, base of interthecal septum being above the level of the preceding aperture, increasing distally to more than ½; proximal thecal spacing 11–12 in 10 mm; distal thecal spacing 9–10 in 10 mm; dorsoventral width proximally 0.65–0.80 mm; at th 10 is 1.40–1.70 mm and most distally is 2.00 mm.

Remarks. Our material so closely resembles that described by Rickards & Garratt (1990) as *M.* cf. *pridoliensis*, from the Přídolí part of the Humevale Formation of Victoria, that we include the latter in synonymy with *M. pridoliensis*. At most, the only difference is the very slightly more slender proximal end of the Yass material (0.65–0.80 mm compared with 0.70–0.90 mm at the level of th 1). From the type material redescribed by Jaeger (*in* Kříž *et al.*, 1986) our material differs only in having the hood slightly less developed.

In Bohemia *M. pridoliensis* is recorded only from the eponymous biozone, above that of *lochkovensis*, whereas our material is unquestionably from the earlier *parultimus* Biozone. Koren′ (1983), however, recorded *M. similis* from the *formosus* Biozone of Kazakhstan, so our record from Yass is not stratigraphically out of place in a global sense; this Kazakhstan material has been redescribed as *M. bessobaensis* Koren′, 1986. The differences between *M. pridoliensis* and other similar species such as *M. prognatus* Koren′, 1983 were discussed by Koren′ (1983) and Rickards & Garratt (1990) and will not be repeated here, but the evolutionary possibilities of the form are outlined in the section on evolution.

Monograptus bouceki Přibyl, 1940

Figs. 4K–N, 12A, 13C

1937 *Monograptus flemingii* (Salter); Sherrard & Keble, p. 313, pl. XV, figs. 4, 5, text-figs. 20–22.
1940 *Monograptus (Pomatograptus) bouceki* Přibyl, p. 71, text-fig. 1, pl. 1, figs. 7, 8.
1952 *Monograptus salweyi* (Hopkinson); Brown & Sherrard, p. 132, pl. VIII, figs. a,b; text-figs. 2b,c.
1967 *Monograptus bouceki* Přibyl; Jaeger (not described), pl. 14A.
1986 *Monograptus bouceki* Přibyl, 1940; Jaeger *in* Kříž *et al.*, p. 331–332, pl. 3, figs. 3, 7–11, 13, 15.
1986 *Monograptus bouceki* Přibyl, 1940; Koren′, p. 97–99, pl. XX, figs. 2–4; text-fig. 15.
1997 *Monograptus bouceki* Přibyl, 1940; Koren′ & Sujarkova, p. 71–73, text-fig. 9B–D,I–L; pl. 1, fig. 8; pl. 2, figs. 1–9.
1997 *Monograptus bouceki* Přibyl, 1940; Koren′ (*in* Nikitin & Bandaletov), p. 97–99, pl. 20, figs. 2–4; text-fig. 15.

[Fuller synonymies are given in Jaeger (*in* Kříž *et al.*, 1986) and in Koren′ & Sujarkova (1997)]

Material. Numerous specimens from locality W834, *bouceki* Biozone, Cowridge Siltstone, Barambogie Creek (AMF 92386, AMF 92388), Přídolí. We have restudied AMF 44608, the specimen illustrated as *Monograptus salweyi* (Hopkinson) by Brown & Sherrard (1952, pl. VIII, fig. b); it is re-illustrated here (Fig. 12A), but does

not appear to be a specimen illustrated by Sherrard & Keble (1937).

Diagnosis. *Monograptus* with more or less straight rhabdosome, but often with a slight dorsal flexure proximally caused largely by the position of the sicula (Fig. 4K); sicula 1.65 mm long (seen, but possibly incomplete); Σ=1.3; apex of sicula below level of hood of th 2; sicula with ventral curvature; dorsal tongue present; proximal dorsoventral width 0.90–1.10 mm; distal dorsoventral width up to 1.50–2.00 mm; proximal thecal spacing 11–12 in 10 mm; distal thecal spacing 9–10 in 10 mm; thecae claw-like in profile with strong development of dorsal thecal wall only; thecal overlap always ½ or less; thecal inclination 35–40°.

Remarks. The Yass material seems to differ from the types only in being a little more slender throughout; indeed Jaeger's (1967) original figure (pl. 14, fig. A: reproduced herein as Fig. 4K) was also of a slightly slender form. Material described by Koren′ & Sujarkova (1997) is a little more robust, but is otherwise identical. *Monograptus bouceki* appears in the eponymous biozone and ranges higher, just into the *transgrediens* Biozone at the top of the Přídolí (Jaeger, *in* Kříž *et al.*, 1986).

Monograptus formosus
Bouček, 1931b

Monograptus formosus jenkinsi n.subsp.

Figs. 11M,N, 13J

1982 *Monograptus* cf. *formosus* Bouček, 1931b; Jenkins, p. 171, fig. 3E.

Material. HOLOTYPE, ANU 35910, only specimen as part and counterpart, from the Elmside Formation, Black Range Road, NW of Yass (see Jenkins, 1982, p. 167); *transgrediens* Biozone, late Přídolí.

Etymology. For Dr C.J. Jenkins, who first described this specimen.

Diagnosis. *Monograptus formosus* with slender rhabdosome no more than 0.88 mm in dorsoventral width; thecal spacing of 8–9 in 10 mm; thecal hook occupying about one half the rhabdosomal width; dorsal thecal wall strongly retroverted, pointing almost dorsally at its distal extremity; free ventral wall inclined at about 15°; thecal overlap very low, less than one sixth.

Remarks. The new subspecies differs from the type subspecies not only in being half as wide but also in having the prothecal wall inclined at a lower angle throughout the rhabdosome (15° compared with 20–30°), in having less thecal overlap (compare Figs. 11M,N with 11K,L) and in having a lower thecal height (up to 1.30–1.40 mm in the type subspecies). The thecal spacing of *M. f. jenkinsi* n.subsp. is identical with that of the type subspecies as described by Jaeger (1967) and Packham (1968) from the Rosebank Shale (Figs. 11J–L herein). The nature of the thecal hooks (not lappets) appears to be the same in both taxa except that they are wider and higher in the type subspecies. *Monograptus uncatus* Koren′ & Sujarkova, 1997 has similar width and comparable thecal spacing.

This is the only occurrence of this species at Yass, other than the stratigraphically lower occurrence in the *formosus* Biozone (Jaeger, 1967; Packham, 1968) which is, as stated above, late Ludlow to earliest Přídolí.

Monograptus hornyi
Jaeger (*in* Kříž *et al.*, 1986)

Figs. 11D–G, 13G

1982 *Monograptus* cf. *angustidens* Přibyl, 1940; Jenkins, p. 169–170, figs. 3F,I–L,O–Q.

1986 *Monograptus hornyi* Jaeger; *in* Kříž *et al.*, p. 330–331, pl. 3, figs. 2, 6: pl. 4, figs. 16–17.

Material. Numerous well preserved specimens, many in three dimensions, from the Elmside Formation, W430, Black Range Road, *transgrediens* Biozone, Přídolí. Figured specimens AMF 102920–21, AMF 102923–24; other specimens are SM X.27113–17 and AMF 102922, AMF 102948–55, AMF 103002–03.

Diagnosis. *Monograptus* with rhabdosome up to 5.5 cm long with a maximum, distal, dorsoventral width of 2.20 mm; proximal end with characteristic gentle dorsal flexure affecting up to 7 thecae, occasionally almost straight; sicula emphasizes dorsal curvature of rhabdosome, but itself is often with strong ventral curvature, so that the extremely robust virgella points proximoventrally; sicula 1.30–1.65 mm long (mean 1.58), apex reaching above the level of the hood of th 1, sometimes to the level of the hood of th 2; thecae strongly hooked and claw-like throughout; overlapping at most ½ half distally; spaced at 12–15 in 10 mm proximally and 9–10 in 10 mm distally; thecal hook is a dorsal hood with little or no growth of the ventral apertural margin; some lateral expansion of the hood is likely; Σ=1.2 mm.

Remarks. Jenkins (1982) placed specimens from this locality in the *M. angustidens–M. uniformis* group, but the mesial and distal thecal overlap of ½ in *M. hornyi* preclude reference to *M. uniformis* as thecal overlap is much greater in the Lower Devonian species group. *Monograptus bouceki* is the most closely-related species, but *M. hornyi* has a shorter sicula: 1.5–1.8 mm in the type locality, 1.4–1.6 mm in the Elmside locality, compared with 1.80–2.22 mm in *M. bouceki* (Jaeger *in* Kříž *et al.*, 1986; Koren′ & Sujarkova, 1997). The Σ values are also lower in *M. hornyi* (1.2 at Elmside; 1.2–1.3, usually, in the type material, compared with 1.2–1.6 in *M. bouceki*). The characteristic proximal curvature of the Elmside specimens contrasts with straighter rhabdosomes of *M. bouceki* from locality W834 (Fig. 2) but specimens of *M. bouceki* described by Koren′ &

Sujarkova (1997) from South Tien Shan do show similar curvature to *M. hornyi* from the Elmside Formation. The known stratigraphical ranges of *M. bouceki* and *M. hornyi* are, respectively, *bouceki* to *transgrediens* biozones and *lochkovensis* to *perneri* biozones; further documentation of these rarely recorded species may establish their morphological and evolutionary limits. *Monograptus hornyi* differs from *M. pridoliensis*, which we also describe from the Yass district in that the latter has less retroverted hoods so that the ventral thecal wall is commonly visible and the hooks appear more beak-like than hooked, especially distally. *Monograptus prognatus* Koren′, 1983 has much greater thecal overlap than *M. hornyi*, already apparent by th 15. The Elmside specimens reach a greater dorsoventral width than in Jaeger's (*in* Kříž *et al.*, 1986) type material, but the latter are shorter rhabdosomes: at comparable lengths the dorsoventral width is the same. The robust virgella seen in the Elmside specimens is a feature of old age and thus is not seen in the type material which only rarely reaches 30 mm long (usually less than 20 mm).

Monograptus perneri Bouček, 1931a

Monograptus perneri elmsidensis n.subsp.

Figs. 11H,I, 13H,I

Material. HOLOTYPE AMF 102922 (part and counterpart) and PARATYPE AMF 103001 both from locality W430, Elmside Formation, Black Range Road, *transgrediens* Biozone, late Přídolí.

Etymology. This subspecies takes its name from the nearby property Elmside (Fig. 1).

Diagnosis. *Monograptus perneri* with unusually narrow rhabdosome, no more than 0.75 mm dorsoventral width, and a slightly straighter rhabdosome than *M. p. perneri* Bouček, 1931a or *M. p. kasachstanensis* Mikhajlova, 1975 but still with dorsal curvature; thecal spacing 10–11 in 10 mm; thecal overlap about a half; thecal hook occupies a third of overall rhabdosomal width; thecal hook retroverted, seemingly pointing proximally; sicula 1.80 mm long, with ventral curvature, apex reaching midway between the apertures of th 1 and th 2, short dorsal process, small virgella; Σ=1.44 mm.

Remarks. *Monograptus perneri elmsidensis* n.subsp. is straighter and conspicuously narrower than *M. p. perneri* and *M. p. kasachstanensis* Mikhajlova, 1975 whilst retaining the overall rhabdosomal aspect and thecal style. The thecal spacing is lower than the other subspecies and the Σ value greater; because of the thin rhabdosome, the interthecal septa are almost parallel to the axis. We have found only the two specimens amongst several hundred graptolites collected at the locality, so it must be considered a rare component of the fauna.

Monograptus sp. indet.

Fig. 4 O

Material. One specimen lacking a proximal end, in full profile and three dimensions, AMF 102889, from locality W834, *bouceki* Biozone, Přídolí. Cowridge Siltstone, Barambogie Creek.

Remarks. This striking specimen has low-angled thecae with an overlap around ½ thecal apertures with thickened lips, and a similarly thickened base to the interthecal septum. It seems to resemble none of the described species at this level, nor any in the late Ludlow. There is a slight geniculum, but apparently no hood, and the ventral apertural lip may be slightly denticulate. It may represent the distal thecae of a biform species. *Monograptus balticus* Teller, 1966 has similar dimensions in its distal thecae but our form has less overlap and lacks thecal hoods; *Monograptus microdon aksajensis* Koren′, 1993 is closer on thecal overlap but this form has thecal hoods on its distal thecae.

Crinitograptus Rickards, 1995

Type species. *Monograptus crinitus* Wood, 1900, by original designation.

Crinitograptus operculatus (Münch, 1938)

Figs. 4P–R

1938	*Barrandeograptus operculatus* Münch, p. 53–68, text-figs. 2a–c; pl. 8, figs. 1, 2, 5, 6, 11; pl. 9, figs. 4, 5.
non 1952	*Monograptus crinitus* Wood; Brown & Sherrard, p. 132–133, text-fig. 2a.
?1955	*Barrandeograptus operculatus* (Münch); Kühne, p. 397–399, figs. 18A–F.
1995	*Crinitograptus operculatus* (Münch); Rickards, fig. 3.2.

Material. Fairly common at localities W171, W827, W828 (AMF 92342, AMF 102891–93, AMF 103104–06, SM X.28032–39), *parultimus* Biozone, Přídolí. Rosebank Shale.

Diagnosis. *Crinitograptus* of typically slender dimensions and fragile appearance, maximum dorsoventral width 0.40 mm, proximally 0.25–0.28 mm; sicula 1.20 mm long; apex well below level of aperture of th 1; Σ=1.7; sicular aperture without noticeable tongue; thecal apertures small, semi-circular excavations with a genicular hood and slightly undulating lateral and ventral margin; thecal overlap obscure, but may be small; proximal thecal spacing 7 in 10 mm falling to 4 in 10 mm most distally; thecae uniform; thecal inclination almost 0°; nema conspicuously more sclerotised than remainder of colony; virgella tiny.

Remarks. Rickards (1995) placed this species in synonymy with the type species *C. crinitus*, but they are here considered

distinct. In the latter the thecal spacing is closer distally (5 in 10 mm proximally, 7 in 10 mm distally) whereas the reverse is true in *C. operculatus*, and the thecal spacing is lower. *Crinitograptus crinitus* is typically a low Ludlow species and *C. operculatus* a Přídolí form in the Yass area. This is the first report of the genus from Australia.

Brown & Sherrard (1952, p. 132, text-fig. 2e) described a specimen (AMF 44615) from one (not specified) of their "*M. bohemicus*" localities as *Monograptus crinitus* Wood. This specimen is less slender and has quite different cited thecal spacings to those seen in our specimens; we conclude that the material represents proximal portions of *Linograptus p. posthumus* which occurs commonly at the "*M. bohemicus*" level.

Neocucullograptus Urbanek, 1970

Type species. *Neocucullograptus kozlowskii* Urbanek, 1970, by original designation.

Remarks. Two forms are described tentatively (perhaps temporarily) under this genus as no other genus appears to be an appropriate place for them. They show neocucullograptine features including the proximal end and possibly typical thecal hooks, but are distinct in their tiny dimensions; in the rock they are inconspicuous in the extreme and might easily be overlooked in the field.

Neocucullograptus? yassensis n.sp.

Figs. 4U–W, 13L,M

Material. HOLOTYPE AMF 92343, locality W828. PARATYPES AMF 92344 (locality W828) and AMF 92346 (locality W827). Both localities *parultimus* Biozone, Přídolí, Rosebank Shale, near crossing of Hume Highway and Derringullen Creek.

Etymology. After the Yass district of New South Wales.

Diagnosis. Minuscule neocucullograptid rhabdosome with a dorsoventral width ranging from 0.20–0.24 mm, more or less straight; sicula 0.75 mm extending about half way along th 1; possible dorsal process; Σ=1.10–1.25; thecae with "hooks" of unknown structure; thecal spacing 7–9 in 10 mm close to the proximal end, 9–10 in 10 mm more distally; free ventral wall almost parallel to rhabdosomal axis with small amount of late prothecal expansion; thecal overlap small, but not clear; thecal "hook" occupying about half the rhabdosomal width; dorsoventral width immediately prior to "hook" is 0.10–0.12 mm.

Remarks. Although the proximal end looks like described neocucullograptines it is much smaller and narrower, with a sicula only half the length of that of *N. inexspectatus* Urbanek, 1970 and only one third that of *N. kozlowskii* Urbanek, 1970. We can equate *N.? yassensis* with no other species group at present; its proper generic attribution must remain in doubt until more material is available.

Neocucullograptus? mitchelli n.sp.

Figs. 4S,T

Material. HOLOTYPE, AMF 102895 (part and counterpart), locality W171, *parultimus* Biozone, Přídolí, Rosebank Shale, near crossing of Hume Highway and Derringullen Creek.

Etymology. After John Mitchell, pioneer geologist in the Yass district.

Diagnosis. Minuscule neocucullograptine rhabdosome with dorsoventral width of 0.50–0.70 mm including "hook"; excluding hooks the parallel-sided metathecal part has a width of only 0.20–0.30 mm; proximal end not known, but thecal spacing constant at 4.5 in 10 mm; thecal overlap obscure, probably small; thecal inclination 0°; thecal hook occupies about half the rhabdosome width; thecal "hook" obscure, apparently facing ventrally.

Remarks. This species is quite unlike any previously-described form in the Ludlow or Přídolí. The thecal "hooks" are quite unlike the apertural hoods in *Crinitograptus*, and are different from the possibly enrolled "hooks" in *N.? yassensis* n.sp. Both *N.? yassensis* n.sp. and *N.? mitchelli* n.sp. **may** have the neocucullograptine style of apertural processes but this is not certain.

Bohemograptus Přibyl, 1967

Type species. *Graptolithus bohemicus* Barrande, 1850, by original designation.

Bohemograptus praecornutus Urbanek, 1970

Figs. 5C–L, 13K

1970 *Bohemograptus praecornutus* Urbanek, p. 301–310, text-fig. 16; pl. 20C; pls 23, 24.
1976 *Bohemograptus arcuatus* Tsegelnjuk, p. 128, pl. 40, figs. 6–9.
?1976 *Bohemograptus urbaneki* Tsegelnjuk, p. 129, pl. 40, figs. 10–12.
1990 *Bohemograptus praecornutus* Urbanek; Lenz, figs. 3Q,R.
1995 *Bohemograptus praecornutus* Urbanek, 1970: Štorch, p. 71–72, text-figs. 3C,I; text-figs. 4A,E,G; pl. 1, fig. 4; pl. 3, figs. 4, 7.
1997 *Bohemograptus praecornutus* Urbanek; Urbanek & Teller, pl. 4, fig. 9.

Material. Numerous specimens from locality W830, *praecornutus* Biozone, late Ludlow, Black Bog Shale, Rainbow Hill, AMF 92303, AMF 92331–34, AMF 92336–38, AMF 102898, AMF 103026–36, AMF 103171–72; SM X.28050–55.

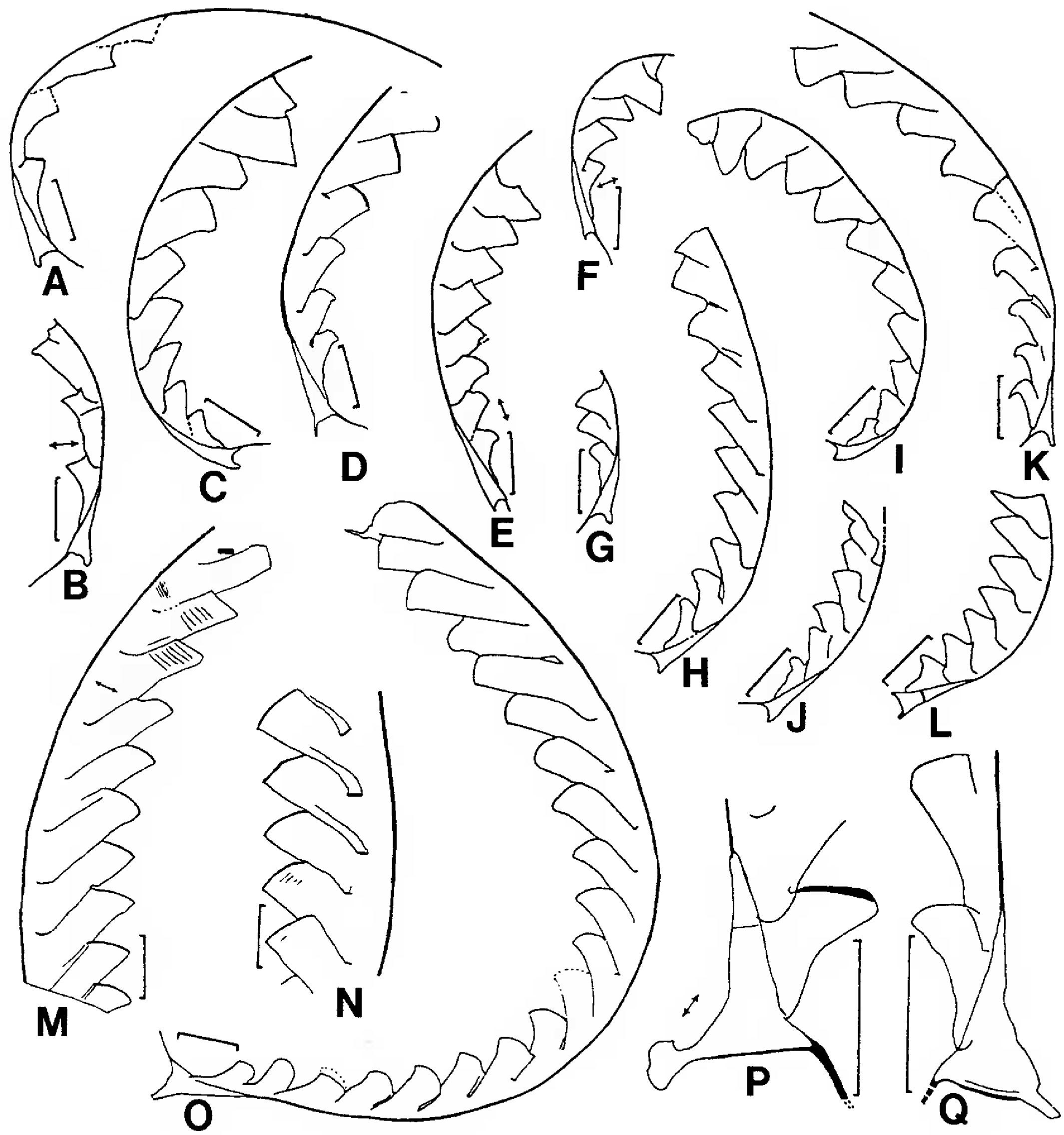

Figure 5. **A,B**, *Bohemograptus bohemicus tenuis* (Bouček, 1936), respectively AMF 92341, AMF 92340, both W830, Black Bog Shale, *praecornutus* Biozone. **C–L**, *Bohemograptus praecornutus* Urbanek, 1970, respectively AMF 92334, AMF 102898, AMF 92338, AMF 92335, AMF 92332, AMF 92331, AMF 92337, AMF 92333, AMF 92303, AMF 92336, all W830, Black Bog Shale, *praecornutus* Biozone. **M–Q**, *Bohemograptus paracornutus* n.sp., respectively AMF 92323, AMF 92311, AMF 92324, AMF 92322, AMF 92302, all W831, top of Black Bog Shale, *cornutus* Biozone. D, K and L show the maximum apertural widening seen in *B. praecornutus*. Scale bars 1 mm.

Diagnosis. *Bohemograptus* with tight ventral curvature and relatively robust rhabdosome with a distal dorsoventral width of up to 1.40 mm at 10 mm from the sicula; dorsoventral width at th 1, 0.45–0.70 mm, at th 10, 0.80–1.30 mm; sicula 1.10–1.50 mm; apex midway between apertures of th 1 and th 2; sicula straight or ventrally curved, with pronounced dorsal tongue directed dorsally; proximal thecal spacing 12–18 in 10 mm; distal thecal spacing as low as 10 in 10 mm; most thecal apertures rounded or with undulating margins; proximal thecae often slightly isolated in profile; thecal overlap about ½ throughout; thecal inclination 40–50°.

Remarks. The sicular length is closer to Urbanek's (1970) type material than to Štorch's (1995) recent description of Bohemian specimens, but our material partly overlaps with both. Otherwise the material is very close to previous descriptions on all counts. One specimen (Fig. 5K) may have the veliger morph features recorded by Urbanek (1970) but is not well preserved; it is the only one possibly showing such features. The differences from *B. paracornutus* n.sp. are discussed under the following description. This is the first report of the species from Australia. Dr T. Koren′ (pers. comm.) has informed us that *B. urbaneki* Tsegelnjuk, 1976 differs from *N. praecornutus*

Urbanek in having a larger sicula with a higher position of the apex, smaller dorsoventral width and weaker gradient of rhabdosomal widening.

Bohemograptus paracornutus n.sp.

Figs. 5M–Q, 6A–N, 7, 9A,B, 10A–E

Material. HOLOTYPE AMF 92317. Figured PARATYPES AMF 92301–02, AMF 92305–08, AMF 92311, AMF 92319–30, AMF 92363–64; other specimens among the available thousands include: AMF 102969–103000, AMF 103054–75, SM X.27178–242. All from from *cornutus* Biozone, late Ludlow, topmost Black Bog Shale, Rainbow Hill, locality W831.

Etymology. This name draws attention to the similar precursor *B. praecornutus*.

Diagnosis. *Bohemograptus* of relatively robust proportions, with strong ventral curvature so that rhabdosomes are approximately semicircular with the thecae on the inside (Fig. 6A,B). Sicula with spectacular apertural expansion so that the sicula is trumpet-shaped; length 1.36–1.52 mm; apex reaching mid way between the th 1 and th 2 apertures; apertural width 0.90–1.50 mm; prosicula about 0.50 mm; metasicular expansion begins sharply when the sicula is about half grown; dorsal sicular lip with pronounced, often winged, process, directed dorsally, proximally or (rarely) ventrally; rest of sicular aperture (the lateral margins) convexly curved, and strongly thickened; virgella robust, spike-like, directed proximoventrally, up to 1 mm long. Dorsoventral width at th 1, 0.60–1.00 mm; at th 5, 0.90–1.30 mm; and most distally up to 2.00 mm; proximal thecal spacing 12–16 in 10 mm, distally 10–12 in 10 mm; th 1 with markedly concave free ventral wall; subsequent thecae have more or less straight free ventral wall inclined at 40–60°, sometimes slightly concave below the apertures; thecal apertures rounded or undulating, thickened, with lateral elevations with arched fuselli; thecal overlap < ½ proximally and > ½ distally; Σ=1.00–1.28.

Remarks. *Bohemograptus paracornutus* n.sp. is clearly very close to *B. praecornutus*, which it resembles in rhabdosome size, shape, thecal type and thecal spacing, and in the position of the apex of the sicula. Both can be contrasted in this last aspect with *B. b. tenuis*, in which the sicular apex is **below** the level of the aperture of th 1 and the whole proximal end is slim rather than robust. *Bohemograptus paracornutus* n.sp. differs from *B. praecornutus* in its spectacularly expanded sicula. All the specimens we have, numbering in the thousands, show this feature; and of all the specimens of *B. praecornutus* we have examined from locality W830 none has an expanded sicular aperture, Figs. 5K,L being the only specimens showing a very slight expansion. The evolutionary relationship of *B. paracornutus* n.sp. to *B. praecornutus* is discussed in the earlier section on evolution of the Yass fauna. *Bohemograptus paracornutus* n.sp. differs from *B. paratenuis* n.sp. (proposed below) in that the latter has the *B. b. tenuis* style of proximal end, that is rather slim and with the apex of the sicula below the level of the aperture of th 1 and thecae inclined at a much lower angle (20°; see Fig. 4X, Figs. 5A,B).

The NSW geological literature is replete with references to *Monograptus bohemicus* or *Bohemograptus bohemicus* from Yass, mostly simply following Brown & Sherrard (1952) and not being based (in many cases) on actual specimens; it is impossible to speculate on the veracity of these records. However, material illustrated by Brown & Sherrard (1952) is here assigned to *B. b. tenuis*.

Bohemograptus paratenuis n.sp.

1970 *Bohemograptus bohemicus* aff. *tenuis* Bouček, 1936); Urbanek, p. 299, pl. 19.

Material. HOLOTYPE: we nominate the un-numbered specimen in Urbanek (1970, Plate XIX, figure B) as holotype. PARATYPES: five specimens figured by Urbanek (1970, plate XIX, figs. A, C, D, E and F). All material figured by Urbanek in Plate XIX is from the erratic boulder S. 234, Mochty, Poland. The repository is the Palaeozoological Laboratory, Warsaw University. The type material was examined by Rickards in 1986.

Etymology. To indicate relationship to *Bohemograptus b. tenuis* (Bouček, 1936), as discussed in the biostratigraphy and evolution section.

Diagnosis. *Bohemograptus* with trumpet-shaped sicula, the apex of which is located below the level of the aperture of th 1, or no higher than it: angle of free ventral wall of th 1, 10–20°, gently concave; origin of th 1 well above the sicular aperture (0.30–0.35 mm); several metasicular thickened bands, one on the pro/metasicular boundary; pseudo-microfusellar additions to thecal apertures; sicular aperture 0.60–0.70 mm with pronounced and winged dorsal process, directed dorsally or proximally; Σ=1.46–1.56.

Remarks. As suggested by Urbanek, this species is close to *Bohemograptus b. tenuis* (Figs. 5A,B, 4X) but shows the same morphological relationship to that species as *B. paracornutus* n.sp. does to *B. praecornutus*, namely the development of a trumpet-shaped sicular aperture. *Bohemograptus paratenuis* n.sp. differs from *B. paracornutus* n.sp. and *B. praecornutus* in having the origin of th 1 much farther away from the sicular aperture, in the much lower angle of inclination of the free ventral wall of th 1, in the greater Σ value, and in the more proximal position of th apex of the sicula. The trumpet shaped sicula is also narrower than in *B. paracornutus* n.sp.

Egregiograptus Rickards & Wright, 1997

Type species. *Monograptus egregius* Urbanek, 1970; by original designation.

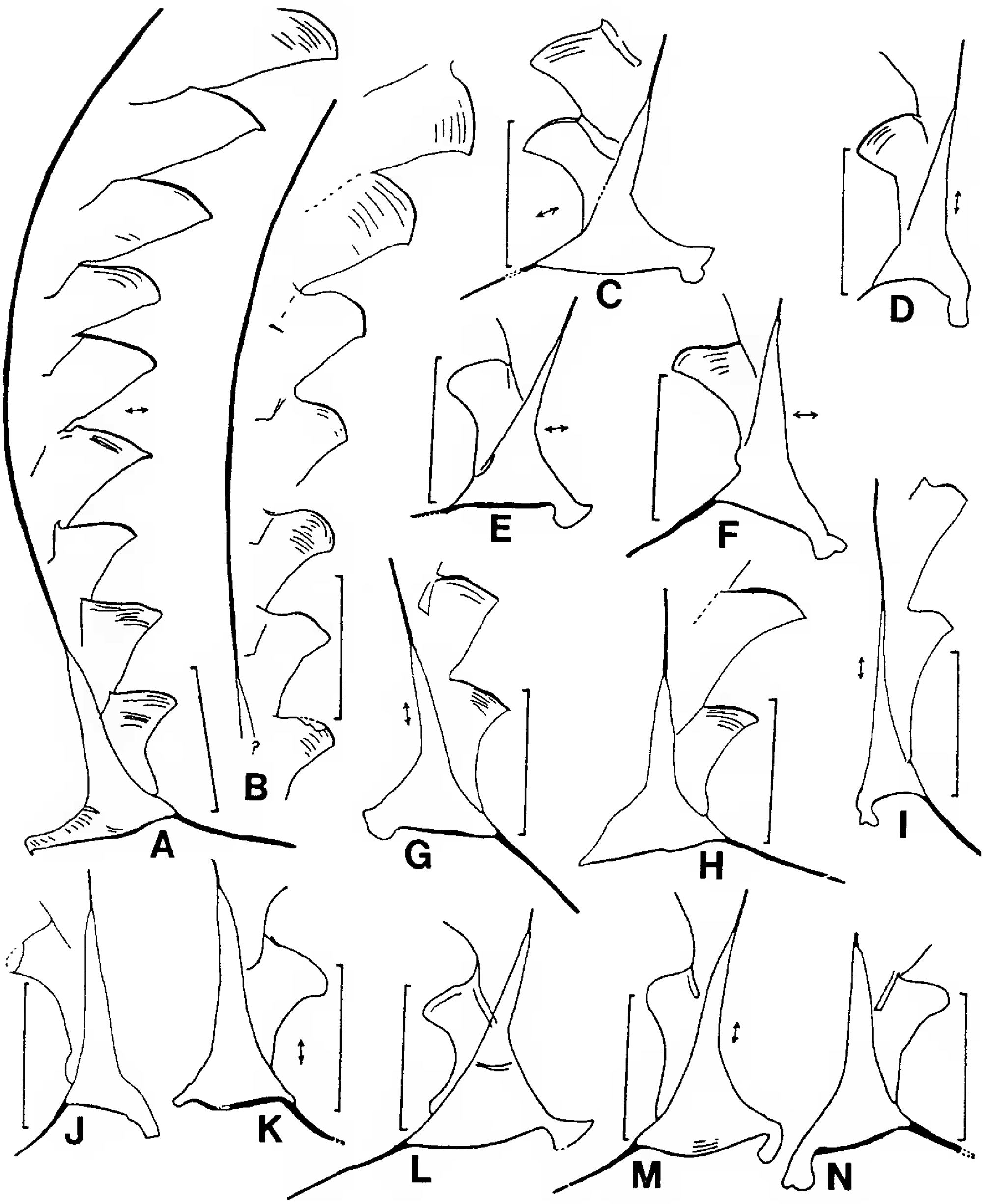

Figure 6. A–N, *Bohemograptus paracornutus* n.sp., respectively AMF 92306, AMF 92305, AMF 92328, AMF 92308, AMF 92326, AMF 92307, AMF 92320, AMF 92319, AMF 92321, AMF 92301, AMF 92325, AMF 92330, AMF 92327, AMF 92329, all W831, top of Black Bog Shale, *cornutus* Biozone. Scale bars 1 mm; tectonic stretching indicated by arrows, where appropriate.

Egregiograptus sp. indet.

Fig. 12C

Material. AMF 44614.

Remarks. Brown & Sherrard (1952, pl. VIII, fig. g) illustrated graptolites on a small slab as *Monograptus roemeri* (Barrande). Most of the specimens are here identified as *Bohemograptus bohemicus tenuis*, but one fragmentary specimen is here assigned to *Egregiograptus*. Sherwin (1979, p. 161) referred this material to the Barrandian species *M. butovicensis*; this species is the type species of *Polonograptus* Tsegelnjuk, 1976, which is a genus that must yet be used with caution (Urbanek & Teller, 1997; Rickards & Wright, 1999) as the type species is poorly known.

Linograptus Frech, 1897

Type species. *Dicranograptus posthumus* Richter, 1875; by original designation.

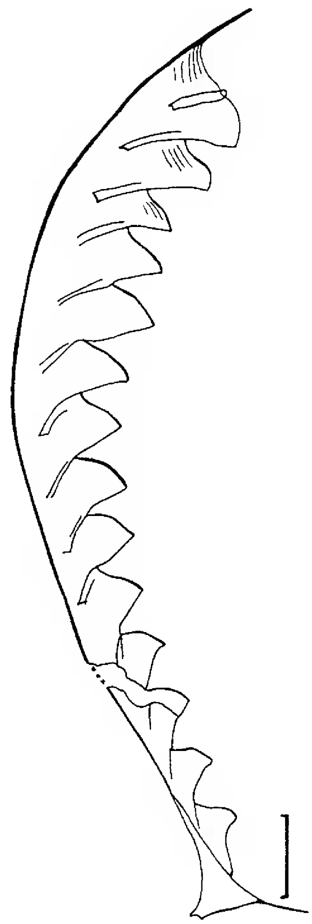

Figure 7. *Bohemograptus paracornutus* n.sp., holotype AMF 92317, W831, top of Black Bog Shale, *cornutus* Biozone.

Remarks. The type subspecies, *Linograptus p. posthumus* (Fig. 8A–C), ranges at Yass from high in the Black Bog Shale in the *cornutus* Biozone to the Přídolí lower part of the Elmside Formation, where it occurs locally in high abundance (Fig. 2). *Linograptus posthumus introversus*, described by us from the late Ludlow Barnby Hills Shale near Wellington, occurs at Yass at collection level 3 (Fig. 8D), a few metres higher than the lowest occurrence of the type subspecies as reported by Brown & Sherrard (1952) as *Monograptus crinitus* (see above under *Crinitograptus*).

Graptolite biostratigraphy

Figure 2 shows the ranges of the Yass graptolites plotted against the established lithostratigraphy, chronostratigraphy and biostratigraphy. Earlier records, such as those of Jaeger (1967), Packham (1968) and Jenkins (1982) are included but not records of out-of-date names in the form of previous identifications, which are listed in Table 1. Most of the species we have listed in Fig. 2 are new records and include several new species. Twenty-seven taxa are recognised, compared with the sparse faunas previously recognised for the Yass area. It is important to recognise that we have not collected through numerous stratigraphic sections, as this is precluded by the exposures: rather, we have collected from mostly previously recognised localities which are well-controlled stratigraphically, as shown on Fig. 1. Placement within a Biozone is not possible in the Yass district occurrences, particularly in view of the discontinuous nature of the graptolite record.

The stratigraphically lowest reported graptolites are all dendroids from the Barrandella Shale Member of the Silverdale Formation in the Yass district and include: those mentioned by Jaeger (1967) from low in the unit; Shearsby's (1912) earlier report; and *Dictyonema* sp. cited by Cramsie *et al.* (1978) from low in the member at Hattons Corner. In a late stage of the preparation of this manuscript, *Dictyonema sherrardae mumbilensis* Rickards & Wright, 1997 was collected from the member in the Yass River upstream from Hattons Corner; we have not seen any dendroid material noted by other authors (Shearsby, 1912; Jaeger, 1967; Cramsie *et al.*, 1978).

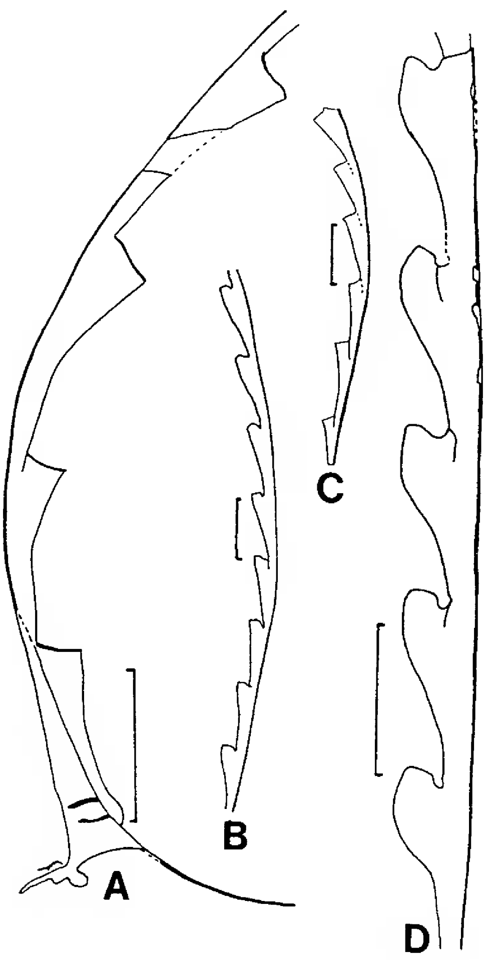

Figure 8. **A–C**, *Linograptus posthumus posthumus* Richter, 1875, respectively AMF 92314, W830, Black Bog Shale, *praecornutus* Biozone; AMF 102897, W171, Rosebank Shale, *parultimus* Biozone; AMF 92367, W830, Black Bog Shale, *praecornutus* Biozone. **D**, *Linograptus posthumus introversus* Rickards & Wright, 1997, AMF 92304, W831, top of Black Bog Shale, *cornutus* Biozone. Scale bars 1 mm.

Figure 9. **A,B**, *Bohemograptus paracornutus* n.sp., W831, top of Black Bog Shale, *cornutus* Biozone: A—AMF 92364, B—AMF 92363. ×5.

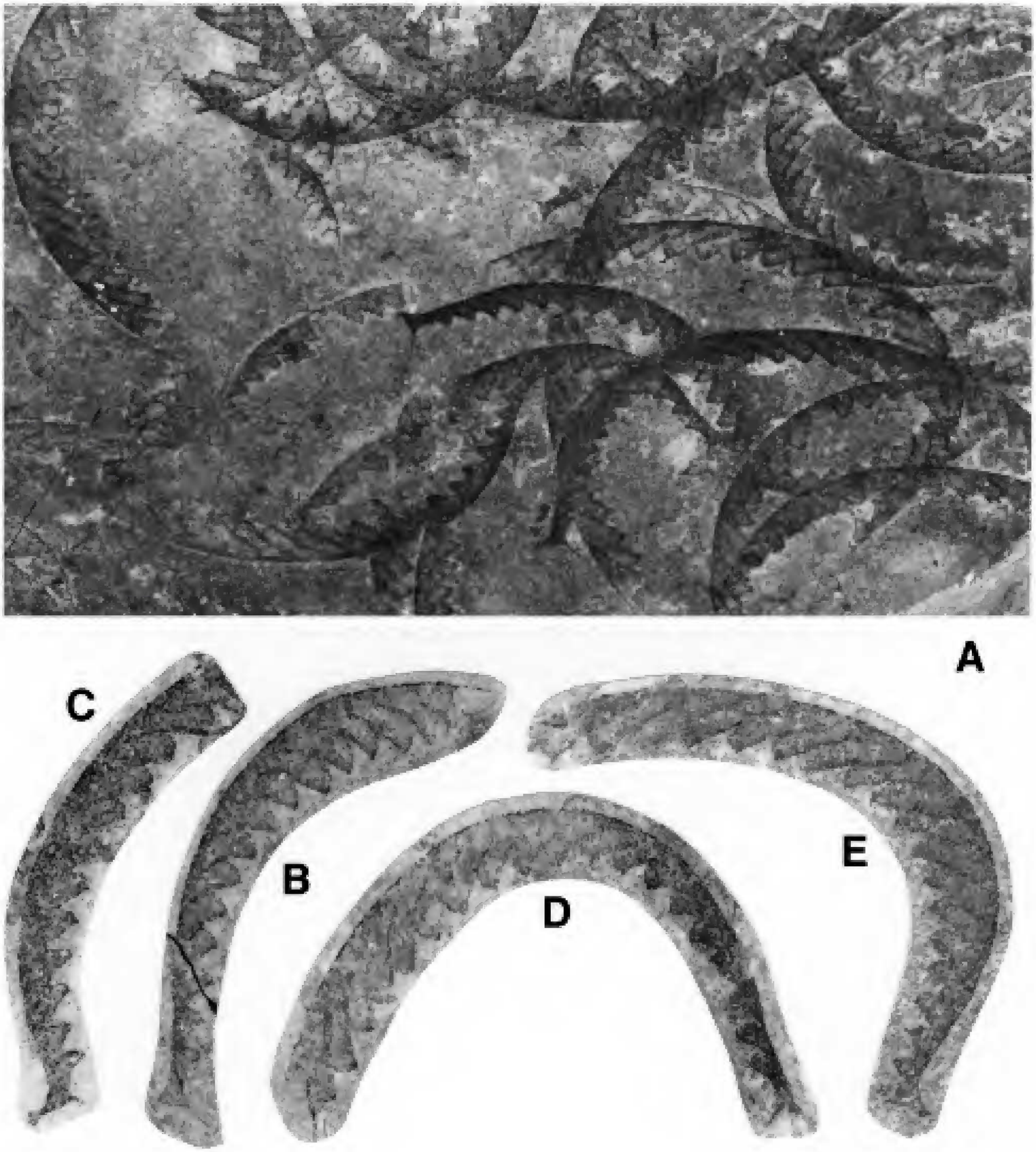

Figure 10. **A–E**, *Bohemograptus paracornutus* n.sp., top of Black Bog Shale, late Ludlow, Rainbow Hill, W831, *cornutus* Biozone, late Ludlow. A, slab AMF 92364, ×5; B, holotype AMF 92317, ×8; C–E, paratypes AMF 92322–24, all ×8.

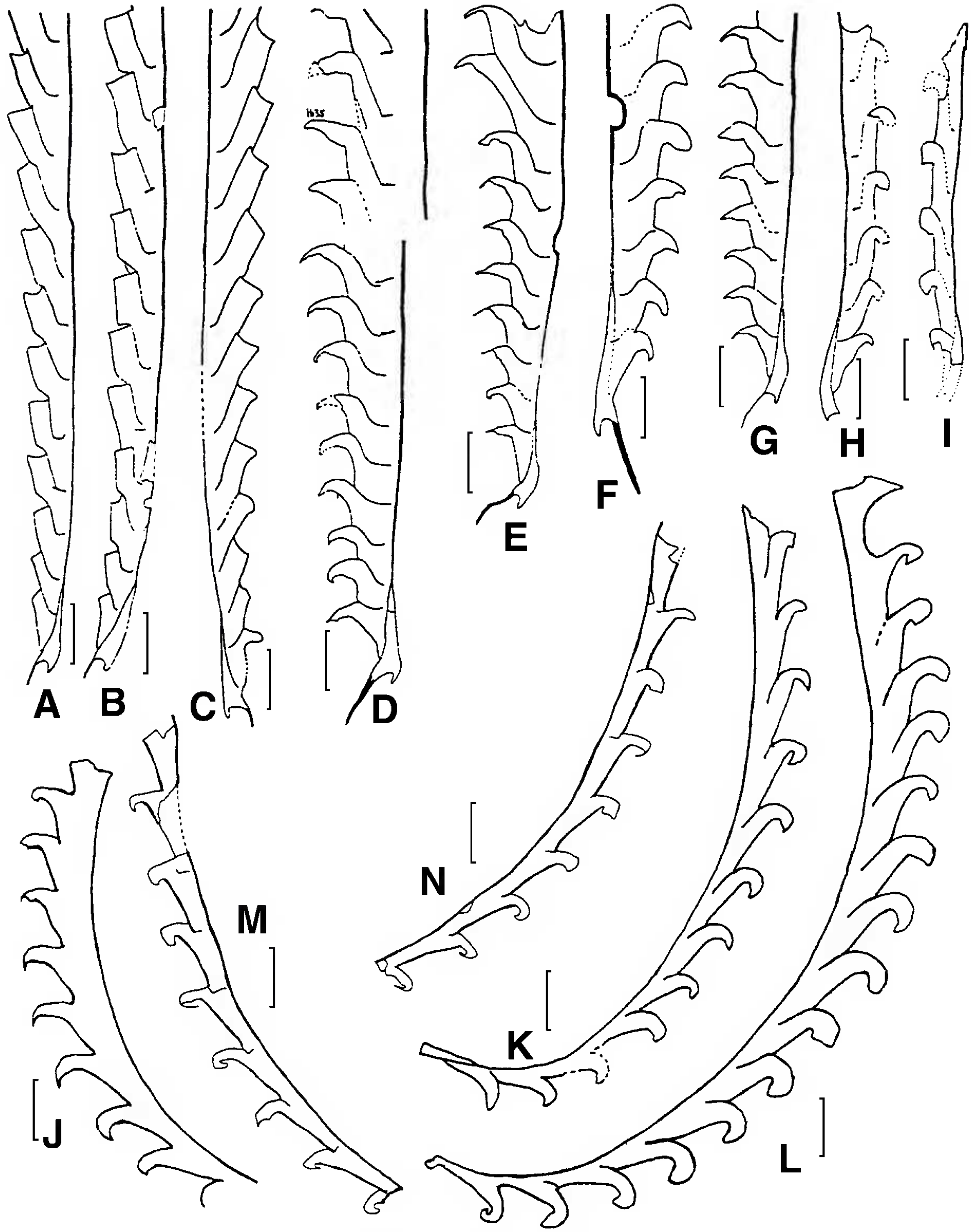

Figure 11. A–N, Graptolites from the Elmside Formation, *transgrediens* Biozone, Black Range Road, NW of Yass, W430. A,B, *Pristiograptus shearsbyi* n.sp., respectively AMF 102925, AMF 102926. C, *Monograptus transgrediens* Perner, 1899, AMF 102927a. D–G, *Monograptus hornyi* Jaeger (*in* Kříž *et al*., 1986), respectively AMF 102920, AMF 102923, AMF 102924, AMF 102921. H,I, *Monograptus perneri elmsidensis* n.subsp., respectively holotype AMF 102922, and paratype AMF 103001. J–L, *Monograptus formosus formosus* Bouček, 1931b, respectively redrawn from Jaeger (1967, pl. 14b,c) and Packham (1968, pl. 11.4: AMF 71942, formerly SUP 23260), Derringullen Creek, Rosebank Shale, level 4 of Fig. 2. M,N, *Monograptus formosus jenkinsi* n.subsp., holotype ANU 35910, part and counterpart. Scale bars 1 mm.

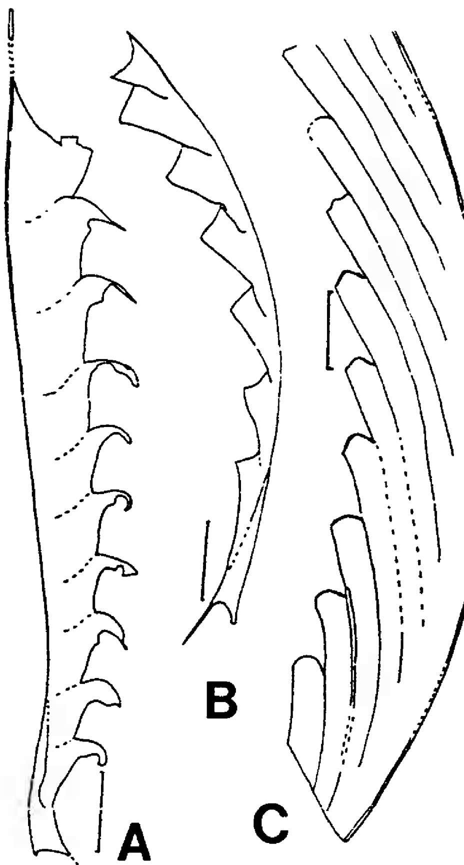

Figure 12. Selected Brown & Sherrard (1952) graptolites. **A**, *Monograptus bouceki* Přibyl, 1940, AMF 44608, Přídolí, Cowridge Siltstone, illustrated as *Monograptus salweyi* (Hopkinson, 1880) by Brown & Sherrard (1952, fig. 2b, pl. VIII, fig. b). **B**, *Bohemograptus b. tenuis* (Bouček, 1936), on same slab as Fig. 12C herein, AMF 44614, Ludlow, from Black Bog Shale (on same slab as *Egregiograptus* sp., but not figured by Brown & Sherrard, 1952). **C**, *Egregiograptus* sp., AMF 44614, Ludlow, Black Bog Shale; illustrated by Brown & Sherrard (1952, fig. 2f, pl. VIII, fig. g) as *Monograptus roemeri* (Barrande, 1850). Scale bars 1 mm.

COLLECTION LEVEL 1. The single specimen we record from our level 1, in the Yarwood Siltstone Member of the Black Bog Shale, is substantially higher stratigraphically than the records mentioned above. The occurrence of *Dictyonema* sp. cf. *D. sherrardae* Rickards *et al*., 1995 at Yass is noteworthy, as it ranges in our collections from level 1 (Ludlow) up to level 4 (Přídolí). The species has previously been recorded as high as the *kozlowskii* Biozone in the Ludlow (Rickards & Wright, 1997) but not in the Přídolí.

COLLECTION LEVEL 2. Locality W830 at Rainbow Hill is where the upper part of the Black Bog Shale has yielded a rich assemblage, including the first record of *Bohemograptus praecornutus* Urbanek, 1970 in Australia.

In his preliminary comments on Yass graptolites from approximately this level, Jaeger (1967) distinguished "two subspecies of *M. bohemicus*", one a "lower subspecies … the classical *M. bohemicus* subsp. A, which has rather simple thecae", and the other "with elaborated proximal thecae and sicula, is confined to the four metres immediately below the *Dalmanites* Bed", at our collection level 3. Jaeger's second form is almost certainly that described in this paper as *Bohemograptus paracornutus* n.sp. It is related to the *B. cornutus* lineages of Urbanek (1970) rather than to the *B. bohemicus* lineages *sensu stricto*. The exact nature of Jaeger's *B. b.* subsp. A is less certain; it may be the form which we describe below as *B. praecornutus* but, if so, its thecae are very similar to those of *B. paracornutus*. Alternatively, it may be that Jaeger identified *B. b. tenuis*, in which case his collection lacked *B. praecornutus*.

The stratigraphic significance is that *B. praecornutus* ranges, according to Urbanek (1970), through the eponymous biozone up into the succeeding *B. cornutus* biozone where it is less common. So locality W830, which yields *B. praecornutus* in abundance some 10–15 m below the *Dalmanites* Bed, is probably referable to the late Ludlow *praecornutus* Biozone, which is in agreement with our other data. Professor T. Koren′ (pers. comm.) has informed us that *praecornutus* ranges through the upper *scanicus, leintwardinensis* and *podoliensis* Biozones in central Asia.

COLLECTION LEVEL 3. Locality W831 at Rainbow Hill is in the top 2–3 m of the Black Bog Shale, and has yielded a small graptolite fauna (accompanied by sparse ceratiocarid debris, and occasional bivalves including *Cardiola* [Sherrard, 1960], ostracodes and small brachiopods) but nothing very distinctive except for the exceedingly abundant, complete, mature specimens of *B. paracornutus* n.sp. As a new species without any other known occurrences, it has no obvious stratigraphic value. However, we argue below, in the section dealing with evolution, that it derives directly from *B. praecornutus*; it is very likely, therefore, that it occurs at the *cornutus* Biozone level. *Bohemograptus cornutus* Urbanek, 1970 is, according to Urbanek (1970), itself a direct derivative of *B. praecornutus*. We have not found *B. cornutus* in the Yass sequence, nor has it been recorded previously from Australia; it is possible that *B. paracornutus* n.sp. and *B. cornutus* occupy different biogeographic provinces. It seems likely, then, that level three is approximately referable to the *cornutus* Biozone in global correlative terms. Presumably there is also a case, which we have not adopted here, for establishing a local *paracornutus* Biozone.

Figure 13 [continued from p. 209]. … **E**, *Pristiograptus shearsbyi* n.sp., holotype AMF 92392, CowridgeSiltstone, Barambogie Creek, W834, Přídolí, ×10. **F**, *Pristiograptus korednikensis* Přibyl, AMF 92353, W827, Rosebank Shale, Barambogie Creek, *parultimus* Biozone, Přídolí, ×10. **G**, *Monograptus hornyi* Jaeger, AMF 102923, Cowridge Siltsone, Barambogie Creek, W834, Přídolí, ×10. **H,I**, *Monograptus perneri elmsidensis* n.subsp., Elmside Formation, W430, Black Range Road, *transgrediens* Biozone, late Přídolí, both ×10; H, holotype AMF 102922; I, paratype AMF 103001. **J**, *Monograptus formosus jenkinsi* n.subsp., holotype ANU 35910, Elmside Formation, late Přídolí, Black Range Road, W430, *transgrediens* Biozone, late Přídolí, ×10. **K**, *Bohemograptus praecornutus* Urbanek, ×8, AMF 102898, Black Bog Shale, Rainbow Hill, W830, Late Ludlow, *praecornutus* Biozone, ×8. **L,M**, *Neocucullograptus? yassensis* n.sp., holotype AMF 92343, Rosebank Shale, Derringullen Creek, W828, *parultimus* Biozone, Přídolí, ×20, L, AMF 92343a; M, counterpart AMF 92343b.

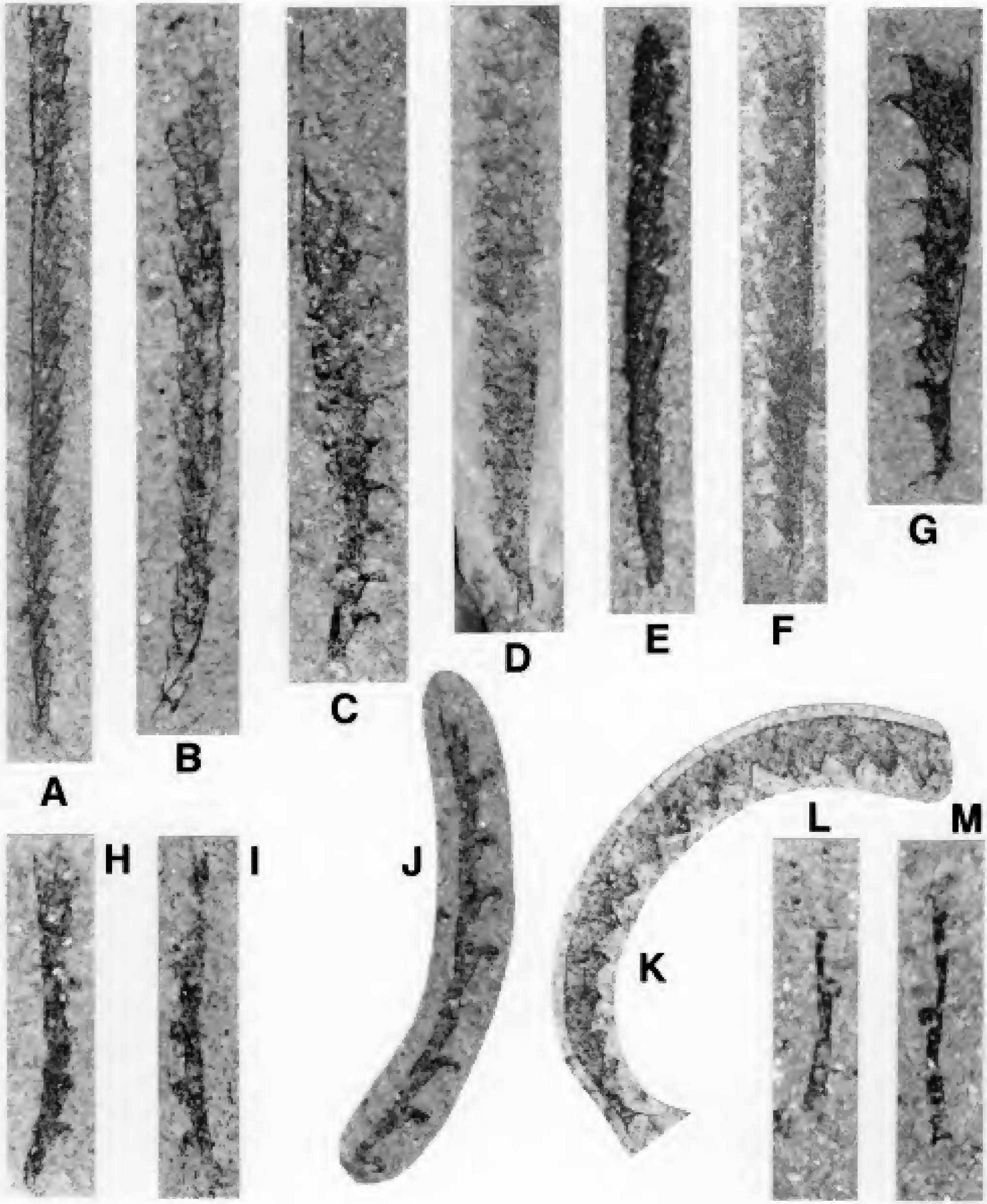

Figure 13. **A**, *Monograptus transgrediens* Perner. AMF 102927, Elmside Formation, Black Range Road, NW of Yass, W430, *transgrediens* Biozone, late Přídolí, ×5. **B**, *Pristiograptus shearsbyi* n.sp., paratype AMF 102925, Elmside Formation, Black Range Road, NW of Yass, W430, *transgrediens* Biozone, late Přídolí, ×10. **C**, *Monograptus bouceki* Přibyl, AMF 44608 (figured by Brown & Sherrard, 1952 as *Monograptus salweyi*), Cowridge Siltstone, Barambogie Creek, Přídolí, ×10. **D**, *Monograptus pridoliensis* Přibyl, AMF 92352, Rosebank Shale, W827, *parultimus* Biozone, Přídolí, ×10. … [Caption continued on p. 208, opposite]

COLLECTION LEVEL 4. The next highest graptolite level, based on localities W171, W827 and W828, is unquestionably referable to the *parultimus* Biozone at the base of the Přídolí. The assemblage in the Rosebank Shale is quite rich, although several taxa occur a little higher than expected. The *parultimus* assemblage appears some 20 m above the base of the Rosebank Shale; thus the interval between collection level 3 (assigned above to the *cornutus* Biozone) and the *parultimus* Biozone is occupied by the Rainbow Hill Marl Member (formerly known as the Middle Trilobite Bed) and an overlying sequence of approximately 20 m of siltstone, shale and fine to medium sandstone. In terms of graptolite biozones this barren 20 m might be roughly the equivalent of the *inexspectatus* and *kozlowski* biozones, but it has yielded no graptolites to us (see Appendix 1 for a fuller discussion of the stratigraphic position of this level).

The base of the Přídolí is, therefore, located some 20 m above the base of the Rosebank Shale, and is marked by the incoming of a striking *parultimus* fauna. The fauna has some unusual features. Firstly, *Crinitograptus* Rickards, 1995 is recorded for the first time in the Přídolí; the species *C. operculatus* Münch, 1938 has been previously recorded from the late Ludlow of northwest mainland Europe. There are also two new minuscule graptolites which we questionably place in *Neocucullograptus* Urbanek, 1970 as *N.? yassensis* n.sp. and *N.? mitchelli* n.sp. The genus has not previously been recorded from the Přídolí and the two new forms are diminutive graptolites even by the standards of the genus.

COLLECTION LEVEL 5. One other locality, shown on Fig. 2 as W835, is the locality in the Rosebank Shale in Reedy Creek (see Fig. 1) from which Brown & Sherrard (1952) described a poorly preserved specimen as *M. vomerinus* (Nicholson); the only specimen we collected from this unlikely locality is ?*M. parultimus*.

COLLECTION LEVEL 6. Localities W832 and W833 are low in the Cowridge Siltstone at "Tulla Park" (Fig. 2) just N of the Good Hope Road. Details of the sparse fauna are given in the appendix; the fauna belongs, like level four, to the *parultimus* Biozone.

COLLECTION LEVEL 7. Locality W834 is in the Cowridge Siltstone in Barambogie Creek. Jaeger (1967) referred the latter level to the *bouceki* Biozone on the presence of the eponymous species, *M. bouceki*, and two forms of *M. transgrediens*. We comment in the Systematic palaeontology section on the latter species provisionally recognising, only *M. transgrediens transgrediens*. We concur with the *bouceki* Biozone attribution which leaves about 30 m of siltstones and sandstones, as yet barren of graptolites, which might be roughly equivalent to the (unproven) *ultimus* and *lochkovensis* biozones of other sequences in the world.

COLLECTION LEVEL 8. Locality W430, in the basal Elmside Formation on Black Range Road (Jenkins, 1982), is almost certainly referable to the latest Přídolí *transgrediens* Biozone. This is the conclusion reached by Jenkins (1982) who interpreted the early form *M.* cf. *angustidens* Přibyl, 1940 (typically low Devonian) as an evolutionary transient from *M. bouceki* to *M. uniformis angustidens*. We reidentify this form as *M. hornyi* Jaeger *in* Kříž *et al.* (1986), a typical Přídolí species. The presence of *M. transgrediens* also suggests a Přídolí age. The *perneri* Biozone, between *bouceki* and *transgrediens* has not been proved in this work, but there is some 50 m of siltstone and sandstone in between the two proven horizons. Jenkins (1982, p. 172) concluded that the base of the Devonian lies at about the middle of the Elmside Formation, between the (lower) sandy unit and the (overlying) shaley unit with limestone lenses yielding the diagnostic Lochkovian conodont *Icriodus woschmidti* (Fig. 2) as identified by Link & Druce (1972).

Biostratigraphy and evolution of the Yass graptolites

Dendroid graptolites. The rare, fragmentary dendroid rhabdosomes are quite well preserved, allowing observation of autothecal details of *Dictyonema* sp. cf. *D. sherrardae* and *D. elegans* Bulman, 1928. The former may be best regarded as the end member of a long-ranging species, first appearing in the *nilssoni* Biozone (Rickards *et al.*, 1995).

Dictyonema elegans is a very long-ranging species appearing in the late Wenlock of the UK; its range was extended into the *nilssoni* Biozone by Rickards *et al.* (1995), and then into the late Ludlow by Rickards & Wright (1997). The autothecal spacing changes up sequence (25 in the Wenlock and early Ludlow; 30 in the *praecornutus* and *cornutus* biozones; and 20 in the very latest Ludlow specimens). When more and better preserved material is available it seems likely that "*D. elegans*" will be divisible into several taxa.

Linograptids. *Linograptus posthumus introversus* Rickards & Wright, 1997 was first described from latest Ludlow strata near Wellington (N.S.W.), so the slightly earlier record herein from the *cornutus* level extends the range slightly; it has only been recorded elsewhere from Romania at about the same level (Rickards & Iordan, 1975). *Linograptus p. introversus* is best considered a short-lived, late Ludlow offshoot of the long-ranging (low Ludlow to Early Devonian), cosmopolitan *L. p. posthumus* (Richter, 1875) as both exhibit thecal introversion; it may prove to have some stratigraphic value. The only other endemic Australian form, the very early Ludlow (*nilssoni* Biozone) *L. orangensis* Rickards *et al.*, 1995 from the Quarry Creek area (N.S.W.), was transferred by Rickards & Wright (1997) to their new genus *Prolinograptus*. *Linograptus posthumus tenuis* Jaeger, 1959 from the Silurian (early Ludlow) *scanicus* Biozone of Thuringia differs in being a tiny form.

Bohemograptids. We have elsewhere (Rickards & Wright 1999) given an account of bohemograptid evolution in a fully global context; in summary, we recognise two main lines of evolution:

1. The *Bohemograptus bohemicus bohemicus* to *B. b. tenuis* line (of which we see late members in the Yass sequence at collection levels two and three); and
2. The *Bohemograptus cornutus* line (of which we record here *B. praecornutus* and its derivative *B. paracornutus*). The appearance of a trumpet-shaped sicula, as in *B. paracornutus*, is a feature seen in only a few lineages (e.g., *Saetograptus fritschi linearis* (Bouček, 1936) and *Monograptus deubeli* Jaeger, 1959) below the Devonian (where, typically, it appears in the *hercynicus* and related lines), and never to the bizarre extent as in *B. paracornutus*.

Pristiograptids. Jaeger (1967, p. 282) noted that "morphologically advanced forms of the long-ranging group of *M. dubius* have been found". However, in the absence of figures, descriptions or specimens (see previous comments about Jaeger's Australian collections) it is difficult to know to what he was referring. From W830 at Rainbow Hill (i.e. *praecornutus* Biozone) we have obtained *Pristiograptus dubius* (Suess, 1851) itself, which is known to range into the Přídolí (see Koren′ & Sujarkova, 1997). We illustrate the form as Figs. 3G–I and note, in our description below, that the sicula has a pronounced dorsal tongue, much more so than in earlier Ludlow forms. It may be this form to which Jaeger referred. However, in the same beds, but more long-ranging overall at Yass (Fig. 2) is *P. shearsbyi* n.sp., a much more slender species than *P. dubius*, but also possessing a (short) dorsal sicular tongue. Jaeger (1967) did not refer to this form and may well have missed it on Barambogie Creek, where it is common and whence he recorded *M. bouceki* and *M. transgrediens*. It seems likely that *P. shearsbyi* is a gracile offshoot of the stem lineage of *P. dubius*; such slender species (as well as broad species) were derived repeatedly from the *P. dubius* lineage from the low Wenlock to the latest Ludlow (Rickards *et al*., 1977, fig. 31), and most were short-lived species rarely lasting more than a couple of zones. By comparison (Fig. 2) *P. shearsbyi* was rather long-lived for such a form, ranging from the *praecornutus* zone (late Ludlow) to the *transgrediens* zone (late Přídolí).

Pristiograptus kolednikensis Přibyl, 1940 is here distinguished from the late Ludlow *P. fragmentalis* (Bouček, 1936) largely because it is less robust (maximum width 2 mm) and has a lower Σ value. *Pristiograptus fragmentalis* is much more commonly recorded, globally speaking, and our specimens do resemble *P. fragmentalis* as illustrated by Koren′ & Sujarkova (1997). The Yass material is, however, noticeably narrower and fits Přibyl's description of *P. kolednikensis* well. Both species must be related to *P. dubius*, but the proximal ends of both are straighter and the earlier thecae are inclined to the rhabdosomal axis at a higher angle. They are best considered late, robust offshoots of the stem lineage of *P. dubius*. The exact horizon of *P. kolednikensis* in Europe is in some doubt, but at Yass it occurs in the *parultimus* Biozone, which is above the range of *P. fragmentalis*. It is thus tempting to suggest that the Přídolí *P. kolednikensis* is a late derivative of *P. fragmentalis* rather than a direct offshoot of *P. dubius*; both differ from *dubius* in their high angle of inclination of th 1 (40–45°), whereas in *dubius* the angle is 20–30°.

Monograptids. *Monograptus pridoliensis* Přibyl, 1981. The evolutionary setting of this species was last discussed by Rickards & Garratt (1990). They supported Koren′'s (1983) proposition that a likely lineage was of *M. pridoliensis* → *M. prognatus* (both Přídolí) → *M. uniformis angustidens* (early Devonian). As Jenkins (1982) and Rickards & Garratt (1990) have shown, *M. uniformis*-like forms do occur in the late Přídolí (respectively *M.* cf. *angustidens* and *M. u.* cf. *parangustidens*). The stratigraphic occurrences of these species, and their morphological features suggest an evolutionary lineage as follows: *M. pridoliensis* (=*M. similis* Přibyl, 1940) in the early Přídolí; leading to *M. prognatus* and *M. bouceki* in the mid-Přídolí; and thence to early morphotypes of *M. uniformis* in the latest Přídolí. The changes involved are relatively subtle and include less biformity of the thecal hoods in the latest forms and an increase in the Σ values as the proximal end becomes more robust (Koren′, 1983).

Monograptus perneri elmsidensis n.subsp. is close to but narrower than the type subspecies and *M. p. kasachstanensis* Mikhajlova, 1975: in view of its occurrence in the latest Přídolí *transgrediens* Biozone, it seems best to regard it as a very late, rare form derived from *M. p. perneri* (*perneri* Biozone, late Přídolí) which it resembles in general rhabdosomal form. *Monograptus formosus jenkinsi* n.subsp., again from the latest Přídolí *transgrediens* Biozone, may well be a late derivative of *M. f. formosus* which occurs in the *parultimus* Biozone at Yass and ranges from late Ludlow to early Přídolí in Europe (Jaeger, in Kříž *et al*., 1986).

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Appendix

Locality data for Yass localities cited

All collection sites (Fig. 1) are located on the Yass 1: 50 000 topographic sheet (8628-S), and all grid references (GR) refer to that sheet. With the exception of the first three localities below which were made earlier by AJW, all collections were made by the authors in December 1997.

W69 Black Bog Shale, Yarwood Siltstone Member (= "Lower Trilobite Bed" of Brown, 1941); Derringullen Creek, GR 713477. Ludlow. Apart from dendroids reported by Jaeger (1967) from low in the Black Bog Shale, and graptolites possibly from this horizon (Shearsby, 1912), this is the lowest known Ludlow graptolite from Yass. *Dictyonema* sp. cf. *D. sherrardae*; collected by AJW in 1972.

W171 Collected by AJW in 1974. GR 715472. This is probably the locality of Packham (1968) and Jaeger (1967) at the crossing of the highway and Derringullen Creek. The small quarry, probably that shown by Link & Druce (1972), was largely destroyed during the construction of the dual carriageway in the early 1970s. It appears to be very close stratigraphically to W827 and W828 (see below). The fauna is early Přídolí, belonging to the *parultimus* Biozone.

The locality lies perhaps as much as 30 m above the base of the Rosebank Shale. Because the Rainbow Hill Marl does not outcrop in this vicinity, the stratigraphic interval separating the Marl from the overlying fossiliferous level is uncertain. It was said by Packham (1968) to be "within a hundred feet" and a label accompanying a specimen in the Australian Museum and written by I.A. Browne states that the interval is as little as 20 ft (ca. 6 m); Jaeger (1967) stated that these beds yielding our *parultimus* fauna "have a maximum thickness of 30 m and immediately overlie the *Dalmanites* Bed" (i.e., the Rainbow Hill Marl Member). The collective fauna from this locality, W827 and W828, as well as taxa recorded by Packham and Jaeger, is: *Dictyonema* sp. cf. *D. sherrardae*; *Dictyonema* sp.; "*Medusaegraptus*" sp.; *Monograptus parultimus* Jaeger, 1975; *M. pridoliensis* Přibyl, 1981; *Monograptus formosus formosus* Bouček, 1931b; *Crinitograptus operculatus* (Münch, 1938); *Neocucullograptus? mitchelli* n.sp.; *Neocucullograptus? yassensis* n.sp.; *Linograptus posthumus posthumus* Richter, 1875; *Pristiograptus kolednikensis* Přibyl, 1940; and *Pristiograptus shearsbyi* n.sp. No associated fauna has been recorded from these localities, although possible plant fragments were noted.

W430 Black Range Road cutting in the lower part of the Elmside Formation (Jenkins, 1982); GR 696447. The sequence consists of alternating shale and fine micaceous sandstone beds; the latter have been the source of all our graptolites and commonly show HCS and shallow water sole markings. Associated fauna (see also Link & Druce, 1972) includes most commonly the brachiopod *Plectodonta bipartita* Chapman (normally cited as a senior synonym of

Plectodonta davidi Brown) occurring as abundant disarticulated, disoriented valves, and *Lissatrypa*; and rare trilobites such as *Kettneraspis rattei* (Etheridge & Mitchell). Large (up to ca. 10 mm) amorphous carbonaceous bodies also occur with the graptolites. The low diversity but well-preserved and abundant graptolite fauna is dominated by *Linograptus posthumus posthumus* and the monograptids: *Monograptus transgrediens* Perner, 1899; *Monograptus hornyi* Jaeger (*in* Kříž *et al*., 1986); *Monograptus perneri elmsidensis* n.subsp., a single specimen of *Monograptus formosus jenkinsi* n.subsp., and the dendroid *Dictyonema elegans* Bulman, 1928. This fauna is late Přídolí. First AJW collections made in 1982.

W827 Low bare shale outcrops on W bank of Derringullen Creek, upstream of motorway bridge. GR as for W171. This locality has yielded the *M. parultimus* fauna, which is listed in its entirety under W171. We have not collected *M. formosus* at this locality, nor at W828.

W828 This locality is about 15 m further W from W827 but has similarly been grouped with W171. GR as for W171 and W827.

W830 Rainbow Hill, about 15 m below the top of the Black Bog Shale; GR 712409; *praecornutus* Biozone, late Ludlow. Fauna includes: *Monograptus bohemicus tenuis* Bouček, 1936; *Monograptus praecornutus* Urbanek, 1970; *Pristiograptus shearsbyi* n.sp.; *Pristiograptus dubius* Suess, 1851; *Linograptus p. posthumus*; *Dendrograptus* sp.; and *Dictyonema elegans* Bulman, 1928.

W831 Rainbow Hill, uppermost 2–3 m of the Black Bog Shale; GR 712409. The fossiliferous strata are layered organic-rich shales with abundant pyrite on bedding planes, although the graptolites are not pyritised. Bedding planes are often covered with overlapping, complete, mature rhabdosomes. The associated very sparse fauna includes: the rare clams (Sherrard, 1960) *Cardiola, Pteronitella rugosa* Sherrard, 1960, *Actinopterella minuta* Sherrard, 1960; and rare small brachiopods, ceratiocarids, ostracodes, nautiloids and trilobite elements. The gradational contact with the shallow water marls of the Rainbow Hill Marl Member of the Rosebank Shale indicates a marked regression. Slight tectonic deformation has produced the normal different appearances of the fossils in the two extreme conditions. The graptolite fauna includes: *Dictyonema elegans*; *Dictyonema* sp. cf. *D. sherrardae*; *Linograptus posthumus posthumus*; *Linograptus posthumus introversus* Rickards & Wright, 1997; *Monograptus paracornutus* n.sp.; and *Monograptus bohemicus tenuis*. Contrary to the statement by Brown & Sherrard (1952), this *bohemicus* fauna was first found by Dr Gordon Packham in 1947 at Rainbow Hill and subsequently material was made available to Dr Ida Brown and Mr A.J. Shearsby (Gordon Packham, pers. comm., 1998). Note that there is some further confusion in locality data given by Brown & Sherrard (1952, p. 130).

W832, W833 Cowridge Siltstone, "Tulla Park", mostly from fine sandstone rubble low in formation, on low ridge west of farm track; GR 724385. The former locality is in the northern part of portion 15, the latter in the southern. This is presumably the "*salweyi*" horizon of Brown & Sherrard (1952, fig. 1). Fauna consists of: *Monograptus parultimus* Jaeger, 1975 and *Pristiograptus shearsbyi* n.sp. As indicated by Jaeger (1967) no monograptids with hooked thecae were found here.

W834 Cowridge Siltstone, Barambogie Creek, GR 693515; all material from float, but apparently derived from no lower than halfway up lower unit recognised by Link & Druce (1972). This locality is close to the "Silverdale" locality of Sherrard & Keble (1937) which was from a ridgetop (portion 34, parish of Derringullen) just N of the creek near the Yass-Boorowa road (Fig. 1). The photograph published by Brown & Sherrard (1952), purporting to be of this Silverdale locality, is a view of Rainbow Hill from the North. Fauna includes: *Dictyonema* sp., *Monograptus transgrediens, M.* sp., *M. bouceki* and *Pristiograptus shearsbyi*.

W835 Rosebank Shale, Reedy Creek. Collecting at this roadside locality was undertaken because Brown & Sherrard (1952) described material from (presumably) here as *Monograptus vomerinus* (Nicholson); our only poor material is a very doubtful *Monograptus parultimus*. GR 698372.